SPECIAL 35th ANNIVERSARY ISSUE

Astronomy®

August 2008

The world's best-selling astronomy magazine

10 BIGGEST DISCOVERIES OF THE LAST 35 YEARS

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Where will astronomy be in 35 years? p. 30

10 top up-and-coming astronomers p. 60

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What is coma? It's not some sort of astronomical state of unconsciousness. It's an optical aberration. Precisely defined, coma is a distortion in which the image of a star cannot be focused to a point, but takes on the shape of a comet. Worst yet, the majority of telescope optical systems, including the popular Schmidt-Cassegrain, have it to one degree or another.

This side-by-side comparison tells the tale. Two images, one camera, one night, and no image processing*. Two very different results. Just look at the magnified view from the Schmidt-Cassegrain on the left. Notice the crescent-shaped distortion of the star images caused by coma. Now look at the magnified image of the same stars from the LX90 and LX200 Advanced Coma-Free™ (ACF™) System and you will immediately see the advantages of the ACF optical system. Sharp, round stars without coma. Sharp from the center all the way to the edge of this wide field.

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*The camera was a Canon 5D Digital SLR with a full 35 mm sensor. All of the above comparisons were taken using the original full frame images without any processing. The above images of M44 were taken by Jack Newton. See for yourself by downloading the two images and viewing them at 100% screen resolution from Meade.com.

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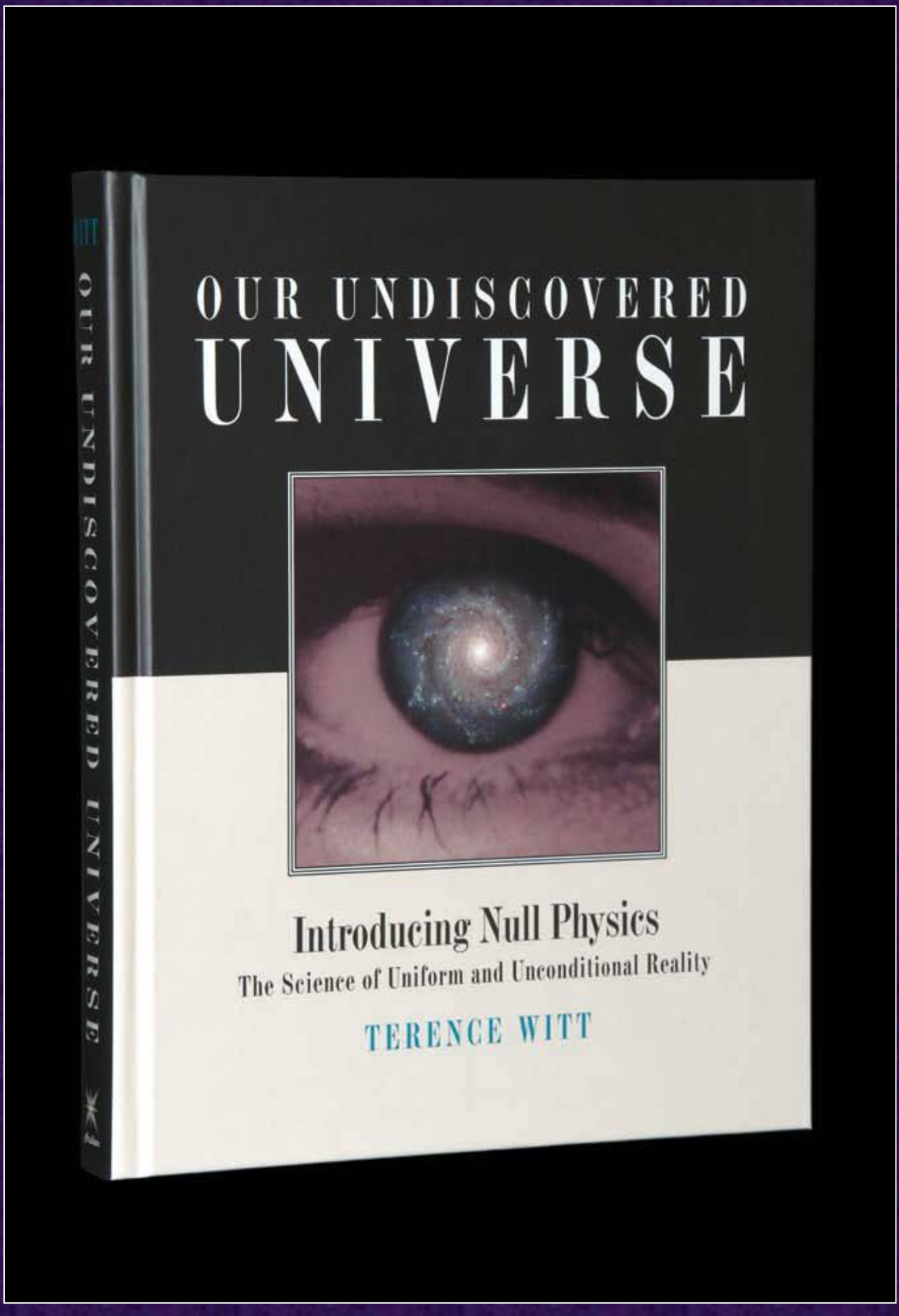
OUR UNDISCOVERED UNIVERSE
OUR UNDISCOVERED UNIVERSE
Introducing Null Physics
The Science of Uniform and Unconditional Reality
TERENCE WITT

Theoretical physics has been hopelessly stalled for over 30 years. Moribund. Ossified. The Standard Model of particle physics uses over 20 ad hoc constants, and no one knows why they are necessary or why they have the values they do. Quantum physics and general relativity remain utterly incompatible. Cosmologists haven't the foggiest idea what could have caused the Big Bang or what, if anything, came before it. And finally, after over 30 years of effort, string theory hasn't even achieved the status of *science*.

There is a very simple reason for this catastrophic, intractable mess. Theorists stopped asking *why* a long time ago. Without the *why*, the search for mathematical symmetries becomes numerology, not science. No telescope or particle accelerator, regardless of its size, is going to tell us *why* the universe is the way it is. When the *why*'s remain unanswered, there is no understanding. When there is no understanding, there is no progress. But this sad situation is about to change forever.

Our Undiscovered Universe is all about the *why*. It's an entirely new paradigm, a premise so powerful that it can finally answer the most important question of all: "*Why does the universe exist?*" This, in turn, reveals many of nature's secrets to a depth and clarity never before imagined.

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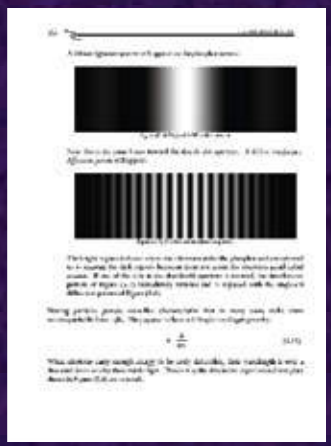
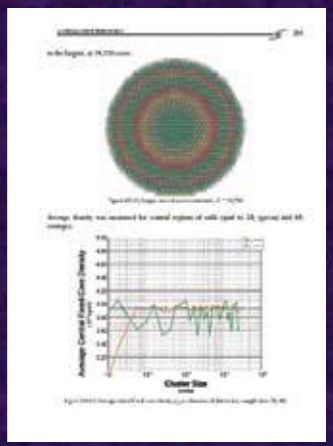
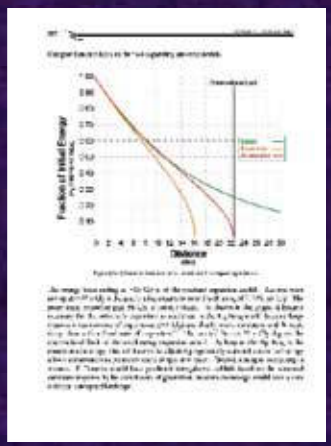
100 years ago, Einstein found a small part of the universe's four-dimensional geometry. Null Physics provides the rest of it. After reading this book, concepts like string theory and the Big Bang will seem positively ludicrous in comparison. Here is a brief glimpse of its sweeping unification:

- Energy is a three-dimensional substance, and its most basic unit is time-distance^2.
- Our universe has only a single fundamental constant: its finite, four-dimensional volume.
- A black hole's peak density is 1.2(10)^{19} kg/m^3, about 60 times more dense than atomic nuclei.

Welcome to 21st century physics

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VOL. 36, NO. 8

Astronomy

The world's best-selling astronomy magazine

August 08

ASTRONOMY MAGAZINE 35th ANNIVERSARY

SPECIAL 35th ANNIVERSARY ISSUE
Astronomy
10 BIGGEST DISCOVERIES OF THE LAST 35 YEARS
BONUS! Foldout timeline history of amateur astronomy

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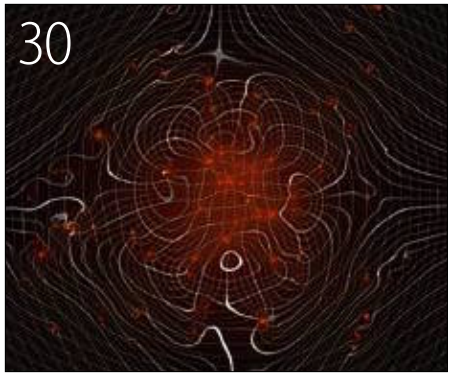

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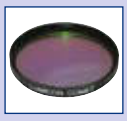

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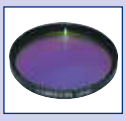

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Astronomy celebrates 35 years

by David J. Eicher

When I arrived in Milwaukee and reported for work September 16, 1982, fresh out of Miami University, I couldn't have imagined the adventure that awaited me. At AstroMedia Corp., Richard Berry was the editor-in-chief of *Astronomy*, Robert Burnham its energetic associate editor, and Bob Maas the company's financial whiz. All three were exhilarating and brilliant to work with. I started as the magazine's youngest assistant editor and was joined by Francis Reddy, who also had just started as an assistant editor.

The magazine was young then, only 5 years past the untimely death of its founder, Stephen A. Walther. AstroMedia had only about 40 employees, and we filled our days writing and printing magazines in a stone building near Milwaukee's lakefront. I had brought along the little magazine I'd founded in high school, *Deep Sky Monthly*, retitled *Deep Sky*, and began publishing it quarterly.

I've been with *Astronomy* for 26 years, and have held every position on the editorial staff. Seeing the transition from a young title that had just taken over as the biggest circulation magazine on its subject, to the present day, with the magazine's longstanding leadership in the field, has been a satisfying experience.

The editorial staff has worked tirelessly to assemble a special collection of stories, including now-Senior Editor Francis Reddy's "Where will astronomy be in 35 years?" (p. 30). It's a bold look at where the science is going in terms of research, discoveries, and technology. Senior Editor Richard Talcott, who has been with the magazine since 1986, gives us a marvelous retrospective in "Top 10 discoveries of the past 35 years" (p. 36). Rich places dark energy at the top of the list — let us know if you agree or disagree with our editors' picks. In "Amateur astronomy's greatest generation" (p. 68), Senior Editor Michael E. Bakich tells us the story of how American skygazing has changed over the past 90 years, from the humble beginnings at the Stellafane gathering in Vermont up to the present. Executive Editor Dick McNally profiles our current staff, an exceptionally skilled and fun bunch, in "Backstage at Astronomy" (p. 76).

We're also proud of the eight-page foldout poster, "*Astronomy* magazine's first 35 years." On it, you'll find a graphic timeline of the magazine's history along with notable events in the science and hobby of astronomy.

We've included a sprinkling of tidbits from articles written during the magazine's lifetime, including Carl Sagan's early piece on the moons of Mars, Richard Berry's coverage of Voyager at Saturn, Bart Bok's piece on the Milky Way, and J. Craig Wheeler's article on wormholes and time travel. We believe you'll like this retrospective poster as much as we enjoyed putting it together.

As *Astronomy* heads into its second 35 years, we continue to be the most-read publication on astronomy in the world. We've worked hard to bring you everything you've asked for in print and on our Website. Please e-mail me at editor@astronomy.com if you have suggestions or comments. Now, I'm going to grab a piece of cake, and I hope you'll join me. Happy birthday, *Astronomy*!

Yours truly,

David J. Eicher
Editor

Astronomy

Volume 36, Number 8

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August web extras

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"Where will astronomy be in 35 years?" p. 30
Travel throughout the Andromeda Galaxy using a Pan-STARRS image.

"Top 10 discoveries of the past 35 years" p. 36
Read about the discoveries that barely failed to make our list.

"10 rising stars of astronomy" p. 60
Learn about these and other emerging stars in astronomical research.

"Ask Astro" p. 74
Discover how astronomers search for and find exoplanets. Plus, more of your questions are answered by astronomy experts.

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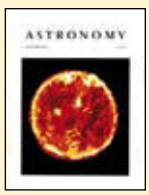

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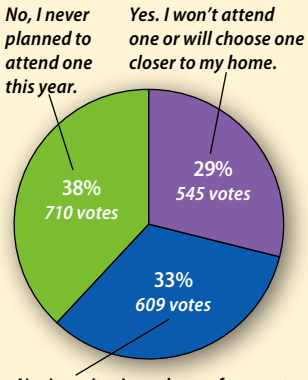
Astronomy Editor David J. Eicher revisits some of the biggest space stories that occurred during the magazine's history.

Online poll results

Will the cost of fuel force you to change your plans to attend a summer star party?


No, I never planned to attend one this year.
Yes. I won't attend one or will choose one closer to my home.
38%
710 votes
29%
545 votes
33%
609 votes
No, I won't miss a chance for great observing because of fuel cost.

Total votes: 1,864

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Globular cluster M13 in Hercules

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Senior Editor Michael E. Bakich guides you through the constellation Hercules the Hero.

THE SUMMER SKY
Contributing Editor Phil Harrington discusses summertime binocular observing.

ASTRONOMY* BRINGS YOU *EXTREME WEATHER
Storm chaser Warren Faidley, a contributor to *Astronomy*'s special publication, tells about his career and how technology has changed in the past 20 years.

Far left, clockwise: N.A.Sharp, REU program/NOAO/AURA/NSF; NASA/JPL/USGS

This month's top blogs

Editors put their spin on current events in the staff blog. You can share your opinions on news headlines and popular culture, too.

1 STEPHEN HAWKING AND THE BIG BRAIN FALLACY
The renowned theoretical physicist believes we are not alone in this universe. **BY DANIEL PENDICK**

2 TRACKING THE GIANT
Discover the largest planet in our solar system in John W. McAnally's new book, *Jupiter and How to Observe It.* **BY MICHAEL E. BAKICH**

Jupiter

3 JOHN ARCHIBALD WHEELER (1911–2008)
Remembering the University of Texas physicist who coined the term "black hole." **BY FRANCIS REDDY**

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Brave new world

In "Mercury surprises reveals its hidden side" (May 2008), I am glad that even astronomers were surprised by the results of the recent flyby of Mercury by NASA's MESSENGER spacecraft. The brief encounter transformed a body once thought to have characteristics similar to those of Earth's Moon into something a lot more special. — **John Huerta,** Warren, Arkansas

Good news about light pollution

I have some good news to report on cities' efforts to control light pollution of the sky. Recently, I attended a workshop on lighting in Atlanta, Georgia. One presenter at the workshop discussed cities that have adopted new streetlights based on light-emitting diodes (LEDs), and cited my hometown, Ann Arbor, Michigan, as one of these.

Having been in downtown Ann Arbor often to see clear-globed incandescent-light fixtures spewing light towards the night sky, it was quite encouraging to see the new LED fixtures. They use the same clear-globed fixtures, but light shines only from the bottom.

It seems the immense cost of sky illumination is getting noticed and communities are taking action. Also, LED street lights provide whiter light compared to the existing incandescent lamps. Additionally, the city has received nearly 100-percent positive feedback about the change. — **Steven Aggas,** Gold Canyon, Arizona

Fusion confusion

I was surprised to read in Bob Berman's column, "Basking in the Sun" (May 2008), that "It took until 1920 for Arthur Eddington to explain how four hydrogen protons fuse together into a helium nucleus, changing matter into energy." Wasn't it Hans Bethe who, in the 1930s, first suggested that nuclear fusion powers the Sun? — **Jake Sigg,** San Francisco

Sir Arthur Eddington, Einstein's English champion, was the one who first noticed the mass deficit of helium as compared to hydrogen, and suggested the fusion of hydrogen into helium might be the ultimate source of the Sun's power. Hans Bethe usually gets credit for first quantifying the reality of nuclear fusion as the Sun's energy source, beyond Eddington's level of speculation, in a one-page letter (with two coauthors) to the editor of Physical Review *(Bethe, 1939).*

This paper came on the heels of Indian astrophysicist Subrahmanyan Chandrasekhar's book, which really established the full scale of mathematical physics in stellar structure and evolution. But Bethe's work came too late, after Chandrasekhar already had written the relevant chapters.

Some think the idea of nuclear fusion in the Sun came even earlier than Eddington (certainly not later), and attribute it to French Nobel Prize winner Jean Baptiste Perrin. — **Bob Berman,** Contributing Editor

High-altitude praise

I got my introduction to astronomy from my Aunt Mary, a high school math teacher, when I was growing up in Fort Worth, Texas. We used to sit on a quilt in the front yard and study the constellations by the hour. From then on, I was hooked on astronomy.

When I got out of the U.S. Navy, I discovered a start-up magazine, called simply *Astronomy,* and subscribed to it. You have been with me ever since, through many editors, columnists, and ever-fascinating articles.

I have now retired, and am building a house and observatory in Colorado. This letter is a "thank you" to all the *Astronomy* staff members, both past and present, who have provided and continue to provide a beautiful window to the heavens above. — **Ernie Parker,** Cypress, Texas

No filter required

I read Steve Coe's "How to observe dark nebulae" (May 2008). I'm wondering what filters may/should or should not be used when viewing the various nebulae in his article. Any suggestions, or was this meant to be a naked-eye-through-the-eyepiece exercise? — **Chris Dudas,** Alpine, California

MESSENGER's first look at Mercury revealed fresh craters and a hint of color. NASA/JHUAPL/CIW

Because the dust and cold gas in dark nebulae do not respond to filters, don't use any to observe this class of object. The best way to see many dark nebulae is through a telescope/eyepiece combination that yields low power and a wide field of view. For others, binoculars give good results. I've found 15x70s work well.

As you read through Steve Coe's descriptions, he often describes how the object looks through a certain size of telescope at a specific magnification. Now, you probably don't own as many telescopes as Steve does (not many do). But, for those objects he describes through telescopes near the size of yours, start as close as you can to the magnification he gives, then try other eyepieces. — **Michael E. Bakich,** Senior Editor

Correction

On page 59 of *100 Most Spectacular Sky Wonders*, the image of NGC 6914 should have the credit "Adam Block/NOAO/AURA/NSF." — ***Astronomy* Editors**

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

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Strange Universe

by Bob Berman

Staring contest

They say it's not polite to stare. Yet that's exactly what we astronomers love to do. But when friends, kids, or some romantic prospect joins us under the sky, we forget prolonged staring doesn't come easily to many people.

Some celestial events create a natural focus. Those who loiter outside the Western Mongolia Burger King August 1 will automatically stare at the 2-minute solar totality.

Ten days later, it's a different story. The Perseid meteors will look fabulous the night of August 11/12, especially after 1 A.M., as the Moon sets and the shower's radiant ascends. But unlike the eclipse, there's no particular place to look. That's no problem for you and me: We'll patiently take in the whole sky from a lawn chair.

In everyday life, however, anyone who stares for an hour, motionless, may earn time in a mental hospital. So on August 11, your friends are simply being normal when they chat while looking at each other, with only quick glances at the sky.

Still, it's a mistake. Perseids meet Earth head-on more than 70 times the speed of a bullet, and streak for only a second or two, tops. Brief glances mean you miss most of them. The slow pace then makes the potential boyfriend or girlfriend antsy. Throw in any negatives — mosquitoes or chilly air, say — and pretty soon astronomy seems right up there with bulimia.

Solution: Give them a reason to stare. Experienced amateurs already do this by delivering a planetarium show to their captive audiences, using those green lasers that are now as prevalent as cheese. "Look, there's Vega and Deneb, forming a triangle with Altair." Good stuff, except newbies can handle only about two dozen star and constellation names. After that, it all sounds the way it does to your dog: "There's blah-blah next to blah-blah-blah." It's easy to overdo the name game.

Here are some lecture secrets for maintaining a good hour of sky-staring. By then, you will have seen dozens of meteors and can call it quits.

The Milky Way

The setting Moon marks the galaxy's center that night. Explain how all the stars revolve around this spot every quarter-billion years. Recount the historic mystery of this glow — how it forms a complete ring under our feet, how its old name "zone of avoidance" arose because no "spiral nebulae" appear here, because it blocks the universe beyond. When friends fully grasp its stupendous structure, go to our "companion universe," Andromeda.

Here are some lecture secrets for maintaining a good hour of sky-staring.

Closer to home

Next, look north to Draco. In the first bend of the dragon's body, focus on a spot halfway between Delta and Zeta Draconis. Earth's axis swivels around this point every 26 millennia. With this as the center, scribe a laser radius to Polaris, and swing a circle. Go clockwise from Polaris to see every North Star in history, including Thuban of the ancient Egyptians. The opposite way around the circle reveals the future. Show how everything currently revolves around Polaris, and predict where major stars will be in an hour.

It's not easy being green

Hop around the heavens and ask friends to find pastel stars and discover which color is missing. Confirm there's no green, just as heated steel glows red, orange, yellow, then white, and would turn blue if it didn't melt first. But never green. Reason: Green can dominate only if the cool and hot ends of a spectrum are both absent. This can't happen.

Looking ahead

Point out where in space our solar system is heading. Around the galaxy's center, 300 times faster than a bullet, we zoom toward Deneb, which retreats at virtually the same speed. Then, the local whooshing of Earth in its little orbit, at "just" 37 times bullet-speed, toward the east when you stargaze at midnight.

Anything you can do …

In the ever-enjoyable game of one-upsmanship, see who can discern the faintest object (M31? M13? Maybe even M33?); resolve the tightest double (try Epsilon Lyrae); best use averted vision (count Pleiades); or perceive the faintest color (top stars of the Great Square are blue and orange at 2nd magnitude). What about Alcyone, the brightest Pleiad? Anyone see this star as blue? Not usually. Its 3rd magnitude marks the normal color cut-off.

Sky-motions, contests, epic galactic designs worthy of Michelangelo, our own planet's travels through the star meadows, colors, and whatever mythology you know. Now the naked-eye heavens come to life. And after seeing a few meteors, trace their paths backward to the radiant. Challenge guests to identify non-Perseid sporadic meteors — 10 percent of the night's inventory — with their totally different trajectories and speeds.

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TMB triplet apo refractors are in stock.

The 130mm f/7 **TMB-130** apochromatic triplet, left, is a *Hot Product for 2007.* Unlike other premium refractors with multiyear waiting lists, this big apo is available now.

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Both scopes have collimatable lens cells, FPL-53 ED glass, a genuine *FeatherTouch* dual-speed rotating rack and pinion focuser (a 3.5" drawtube model on the TMB-130, and a 3" on the TMB-92), case, and more.

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Observing Basics

by Glenn Chaple

The King's astronomer

Imagine that you've been granted a private audience with anyone you choose, living or dead. Would you opt for someone famous — a renowned world leader, a legendary athlete, or a movie star?

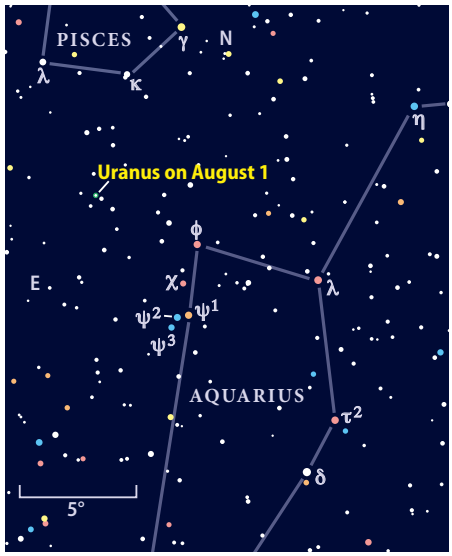
I'd choose Sir William Herschel (1738–1822), one of the greatest observational astronomers of all time.

Born in Germany in 1738, Herschel started out not as a scientist, but as a musician. In his teens, he moved to England, establishing himself as a reputable composer, conductor, and music teacher. Herschel might have continued in music if he had not developed a passion for astronomy while in his mid-30s. Dissatisfied with a borrowed telescope, Herschel taught himself the art of telescope-making. Not one to do things on a small scale, he was soon plying the heavens with home-built reflectors of unparalleled size and quality.

Unlike his predecessors who made random telescopic excursions into the night sky, Herschel worked systematically, dissecting the cosmic dome with surgeon-like precision. During these surveys, this diligent astronomer discovered and cataloged thousands of double stars, star clusters, and nebulae. Among Herschel's many firsts were the discovery of double stars' binary nature, mapping the Milky Way based on observation, and determining the motion of the Sun and solar system in the direction of the constellation Hercules. His work wasn't limited to deep space. Herschel also made significant contributions to solar, lunar, and planetary astronomy.

Although Herschel was known for many accomplishments, one secured his place in history. On the evening of March 13, 1781, he chanced upon an unusual looking star near Eta Geminorum. When subsequent observations revealed the object's motion relative to the background stars, Herschel assumed it was a distant comet. Further studies by the astronomical community led to an indisputable truth — Herschel had discovered a new planet twice as far from the Sun as Saturn!

King George III rewarded Herschel with a pension that allowed him to engage full-time in astronomical pursuits. To honor his patron, Herschel named the new planet *Georgium Sidus* (George's Star), an idea that proved unpopular outside of England. The name Herschel was suggested, but Uranus was chosen, in keeping with the mythological nomenclature of the other planets.



Uranus moves less than a degree during August. Looking at the planet through a telescope, sketch your views at the month's beginning and end. Afterward, see if your illustrations show Uranus' subtle movement. *Astronomy:* Roen Kelly

Like the other gas giants — Jupiter, Saturn, and Neptune — Uranus has an extensive atmosphere rich in hydrogen and helium, a ring system, a swarm of moons (27 at last count). Although much smaller than Jupiter or Saturn, Uranus is still an imposing body — four times larger in diameter than Earth. What sets Uranus apart from the other solar system planets is the extreme tilt of its axis. It tips so drastically that, at times during its 84-year orbit around the Sun, Uranus literally rolls across the sky.

The finder chart on this page shows Uranus' location August 1. You'll have no trouble spotting the 6th-magnitude planet with binoculars or optical finders about 5° south of the star Kappa Piscium in the Circlet of Pisces. Transforming Uranus the star into Uranus the planet requires a scope that magnifies at least 100x — its 4" disk equals the apparent size of a table tennis ball over 1.25 miles (2 kilometers) away!

Due to a lack of readily observable detail, the backyard astronomer who sees Uranus for the first time is unlikely to return for a second visit. Inspect the planet closely, however, and the beauty of its minute bluish disk will surprise you. When gazing at Uranus, I'm reminded of a scaled-down version of some of the finer planetary nebulae.

What would I discuss with Herschel? I'd bring him up-to-date on key astronomical discoveries made since his time, pointing out how his observational techniques set the standards for modern-day astronomy. I'd glean a few historical tidbits from someone intimately familiar with the workings of late 18th and early 19th century science. Maybe Herschel would agree to perform one of his oboe concertos!

For a fitting conclusion, I'd invite Sir William outside to take a look through my telescope at the planet that made him famous. Why not join us? If you've never seen *Georgium Sidus* or you've been away for a while, take time this month for a visit.

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com. Next month: We'll explore the cataclysmic variable star SS Cygni. Clear skies!

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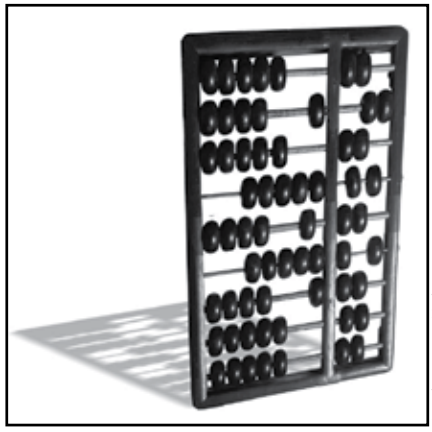

© Andrew Unangst/Corbis.

The abacus is a calculating tool used by many cultures.

About Your Professor

David M. Bressoud is the DeWitt Wallace Professor of Mathematics in the Department of Mathematics and Computer Science at Macalester College, where he has also served as Chair of the department. He earned his Master's and Ph.D. in Mathematics from Temple University.

A former Fulbright Fellow and Sloan Foundation Fellow, Professor Bressoud has served as Visiting Professor at the Institute for Advanced Study and the Mathematical Association of America's Pólya Lecturer, and has received the Mathematical Association of America's Allegheny Mountain Section Distinguished Teaching Award.

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Binocular Universe

by Phil Harrington

Exploring a Messier line-up

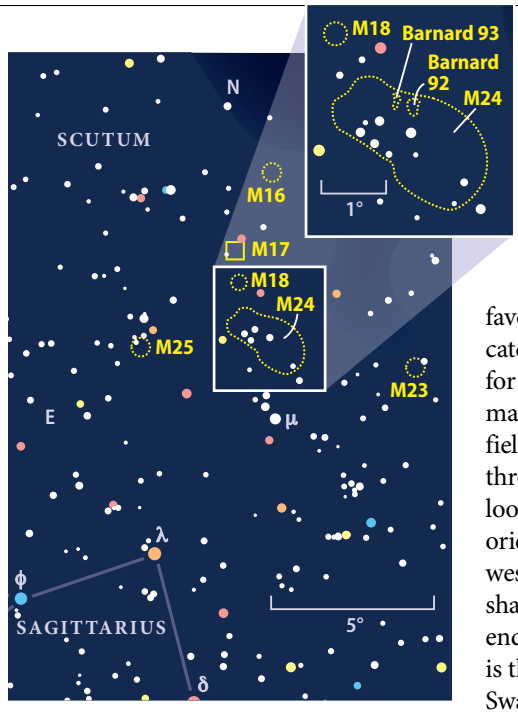
If it's August, then it's time for the annual Stellafane convention in Springfield, Vermont. By day, amateur telescope-makers will hold a friendly competition. Then, at night, our eyes will turn upward to the beauty of the summer sky.

Stellafane attendees had ample opportunity to explore the universe last year, with two clear nights of viewing. While many skygazers crowded in lines to gaze through some of the magnificent telescopes available, several fellow binocularists and I set up our own little enclave of tripods and chairs so that we could share with one another the excitement of the two-eyed Milky Way. After all, this stuff is contagious.

As I scanned the galaxy, I paused not far to the north of Sagittarius' Teapot at the **Small Sagittarius Star Cloud (M24)**. Referring to M24 as a star cloud, however, is not accurate — we're not looking at a cloud at all. In fact, M24 is nearly cloud-free. We actually are peering through a clearing in the opaque dust clouds that pollute the surrounding Milky Way. M24 is more of a picture window opening inward along the Sagittarius spiral arm twisting toward the core of our galaxy. The four brightest stars in the clearing form a kite-shaped asterism, while fainter stars, too numerous to count, flood the surroundings.

The window hasn't been cleaned in a while, however, since we find a couple of dust bunnies on it. Those two patches are **Barnard 92** and **Barnard 93**, a pair of opaque dark nebulae first cataloged by American astronomer Edward Emerson Barnard in 1919. Barnard 92 looks like a small, oval hole on the northwestern edge of M24. Can you spot it?

Next, try your luck with Barnard 93 just to the east. In photographs, it resembles a thin, black comet with a roundish coma at its northern tip unfurling into a feathery "tail" extending to the south. But because of its small size in our sky, you'll need at least 15x magnification to see it as a comet. You'll also need extremely dark conditions to see either of these tough targets, because light pollution wipes out dark nebulae.



The Teapot's lid provides a good launching point to begin your binocular tour through Sagittarius and Serpens. *Astronomy:* Roen Kelly

More binocular Messier objects surround M24, like curtains around our galactic window. Immediately to the west, or right, of M24 is **M23**; about an equal distance to its east is **M25**. Both of these bright open clusters were also discussed in this column 2 years ago. They are always fun to revisit.

North of M24, along the hazy lane of our galaxy, lie three more Messier gems.

We first meet up with open cluster **M18**, nestled just north of three evenly spaced, golden stars. Of all the Messier clusters in this area, M18 is the least impressive through our binoculars. The brightest stars in this open cluster are set in a triangular pattern and may just be glimpsed in 10x50s, but only under dark conditions. The rest blend into a small splotch of hazy starlight.

The **Swan Nebula (M17)** is one of my favorite summertime targets and an easy catch through nearly all binoculars. Look for it just to the south of a yellowish 5th-magnitude star, maybe half a binocular field north of M24. If you're viewing through 50mm and smaller binoculars, look for a straight "bar" of grayish light oriented more or less southeast-northwest. Larger binoculars add a faint hook-shaped appendage curving off the western end of the bar. This hook-and-bar shape is the reason M17 is also known as the Swan Nebula. Through telescopes, the bar represents the swan's floating body, while the hook turns into its long, graceful neck and head. My 16x70 binoculars portray the swan as floating upside down. Telescopes, of course, invert the view to show the swan is alive and well.

Finally, move northward into Serpens the Snake to observe the **Eagle Nebula (M16)**. Here, we find the "Pillars of Creation," one of the Hubble Space Telescope's most famous images. Although the pillars elude our binoculars, we can still enjoy M16 as a small, tightly packed star cluster surrounded by a faint glow. The Eagle requires a special night to be seen at its best, however, since the nebula is easily extinguished by haze and light pollution.

Questions or comments? E-mail me at phil@philharrington.net. Next month, we'll look at the wispy Cygnus Arm. Until then, remember that two eyes are better than one.

Read about binocular prisms at www.Astronomy.com/toc.

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Secret Sky

by Stephen James O'Meara

Vanishing acts, part 2

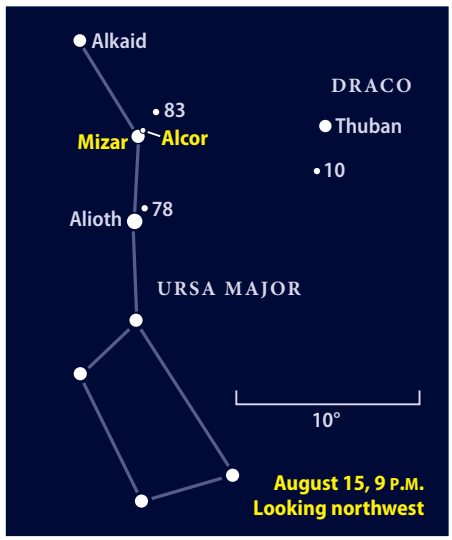
When the Sun goes down in August, and lingering twilight fades, look about halfway up the northwestern sky to the Big Dipper. Use the finder chart on this page to find Mizar, the second star from the end of the Dipper's handle. Take a good look at this star. Do you see anything peculiar? If you have normal vision, you should see that Mizar has a faint visual companion, named Alcor, very close to it. While seeing Alcor is no exceptional feat of visual acuity, the star's visibility can teach us something about how the eye perceives light.

Alcor has an interesting visual history. The 13th-century Persian astronomical writer Zakari'ya Al Kazwini tells us that people tested their eyesight by seeing this star. Apparently, the recycling of this tale over the years molded it into a legend: If you lived in ancient times and could see Alcor with the naked eye, you were recruited into military service. That sounds cool, but I've never seen an original source for that claim. If you have evidence, please e-mail it to me at someara@interpac.net.

The 19th-century observer William Henry Smyth cautioned us about misinterpreting the significance of seeing Alcor with the unaided eye; "But they are wrong who pronounce [Alcor] to be an Arabian word importing sharp-sightedness." Instead, Smyth said, Alcor's visibility gave rise to an Arabic proverb: "Thou [can] see Alcor, yet [can] not perceive the full Moon."

The proverb's point (which is reminiscent of another old saying, "You can't see the forest for the trees") is that if you concentrate too much on minutia, you can miss the larger picture.

Fans of Sir Arthur Conan Doyle's Sherlock Holmes mysteries probably are familiar with the fictional detective's observation techniques. Holmes usually begins by observing a scene, or a person, with "one of his quick, all-comprehensive glances." He then zeros in on certain details before scoping back out and making a logical deduction to explain what he has seen.



The Big Dipper provides a quick eye exam: Can you separate Mizar and Alcor? If so, you have at least normal vision. This chart shows stars 5th magnitude or brighter. *Astronomy*: Roen Kelly

When it comes to separating Alcor from Mizar, the devil is in the details. I've seen some observers, especially beginners, avert their gaze and fail at the task. The solution to that problem is elementary. Like Holmes at a crime scene, you simply have to know how to look before you can see.

Devilish tricks

As I described in last month's column, averted vision is one of the cornerstones of amateur astronomy. To see a dim star, we want its light to fall onto the eye's retina, which is lined with night-sensitive rod cells. These cells excel at detecting dim light at night, making it appear more prominent in the brain.

While it's true that we should use averted vision to see faint stars more clearly, the rule breaks down with certain pairs of stars. Using it on Mizar and Alcor, for instance — especially to the extreme — will cause Alcor to vanish!

Ursa Major's asterism, the Big Dipper, hovers in late September 1983 above the geyser Old Faithful in Yellowstone National Park in Wyoming. Dewey Vanderhoff

Besides your eyesight and experience, four critical factors affect the visibility of naked-eye double stars:

1. The closer the stars, the more difficult they are to separate.

2. A faint star near a bright star is more difficult to detect than two stars of near-equal brightness.

3. Bright pairs are harder to distinguish under dark skies than in twilight due to increased contrast.

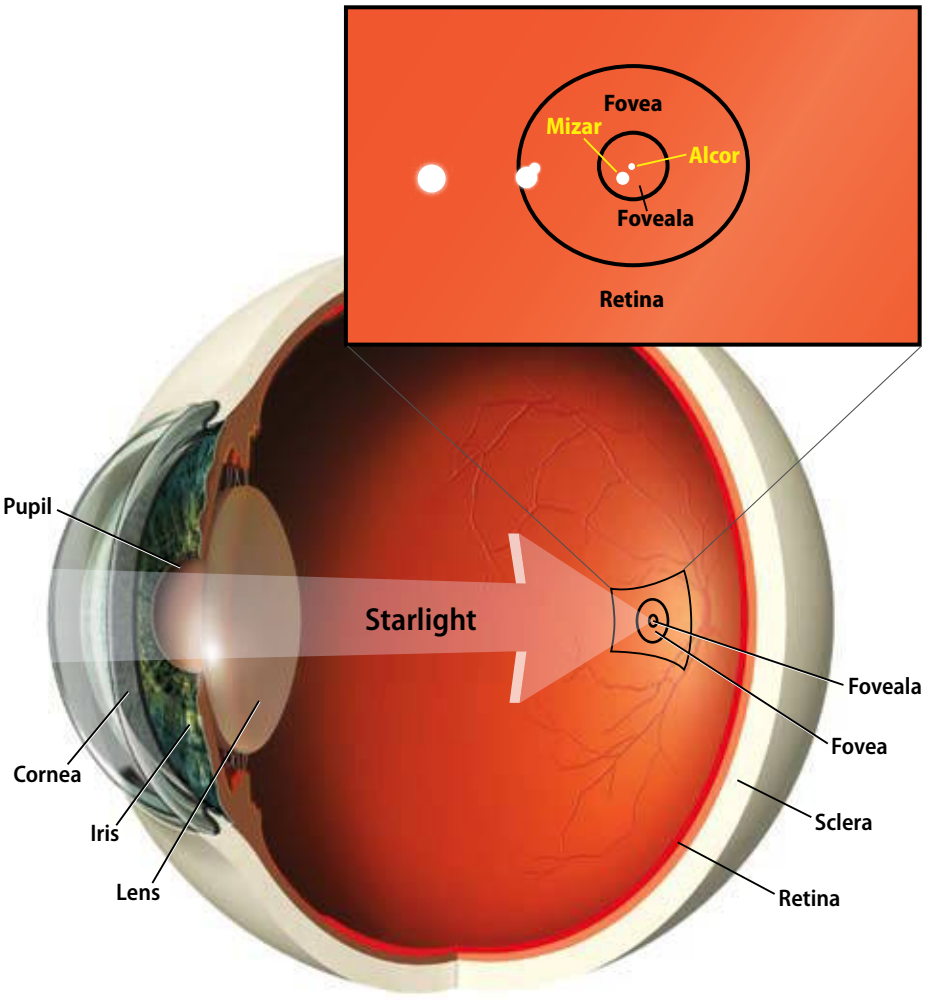
4. Imperfect sky conditions can dampen visibility.

Mizar and Alcor are not particularly close, but they do have disparate brightnesses. The stars shine at 2nd- and 4th-magnitude, respectively, and are separated by 12′ — a little less than half the apparent size of the Full Moon. Since the best eyes can resolve stars to within 3′, the challenge really is not that difficult. In fact, splitting the pair is a good test of average vision.

The best time to attempt a sighting is in deep twilight, just before the sky turns completely dark. That's because Mizar, which is a little more than six times more brilliant than Alcor, appears even more dazzling to the eye under the cloak of darkness, which is distracting.

However, the unspoken key to success is placement. Use direct vision when trying for Alcor. As I described in last month's column, greatest visual acuity is achieved when incoming light strikes the eye's foveala — the fovea's central region. Here, only cone cells, responsible for resolution, are present.

Without optical aid, normal eyes should be able to detect stars of 4th-magnitude or brighter in the foveala. Since the foveala has an apparent visual field of up to 30′ — the apparent diameter of the Full Moon — Mizar and Alcor should fit comfortably within it. If you cannot see, or hold Alcor steady, in the foveala, don't fear. The surrounding fovea, which has a visual field of some 2° to 3°, contains both rods and cones, giving you plenty of extra seeing room.



The appearance of Mizar and Alcor depends on which part of the eye is used. The stars are sharp and clearly separated in the foveala, but begin to blur at the edge of the fovea. They appear as one when viewed with extreme averted vision in the retina. *Astronomy*: Roen Kelly

Mizar and Alcor are separated well in this view captured through a 3.15-inch telescope. This close-up also reveals Mizar's stellar components A and B. Damian Peach

I find that I can resolve Mizar and Alcor reasonably well if I avert my gaze 2° to the side. If I extend that to 3°, the stars appear elongated (like a tenpin) with no clear separation. Beyond that, when the stars cross from the fovea to the retina, they blend and become one; proof that the retina has poor resolving power. Use the chart on this page to see how far you can extend your gaze before you lose sight of Alcor.

Zooming back out

I'd like you to break your concentration. Take a visual step back, and inspect the third star from the end of the Dipper's handle. Alioth shines at 2nd magnitude and has a distant 5th-magnitude companion, 78 Ursae Majoris, 1° to the east-northeast. What happens when you stare directly at Alioth? Can you see 78 Ursae Majoris, as well? What happens to the two stars when you avert your gaze? Do they blend together or do both become more prominent? Be sure to e-mail your observations to me at someara@interpac.net.

By the way, Mizar and Alcor are part of a larger picture. They belong to the Ursa Major Moving Cluster, whose bright core consists of five of the seven stars in the Big Dipper. Mizar is 78 light-years distant, and Alcor is 3 light-years farther away (as are Alioth and 78 Ursae Majoris). Despite their apparent closeness in the night sky, Mizar and Alcor probably do not orbit one another as do true binary systems — even though they are partners sailing through same corridor of space.

A new star Astronomers have discovered a new type of star called a pulsating carbon white dwarf. The star represents the first new class of variable white dwarf discovered in more than 25 years.

For the latest news on space discoveries, spacecraft missions, and sky events, visit **Astronomy.com/news**

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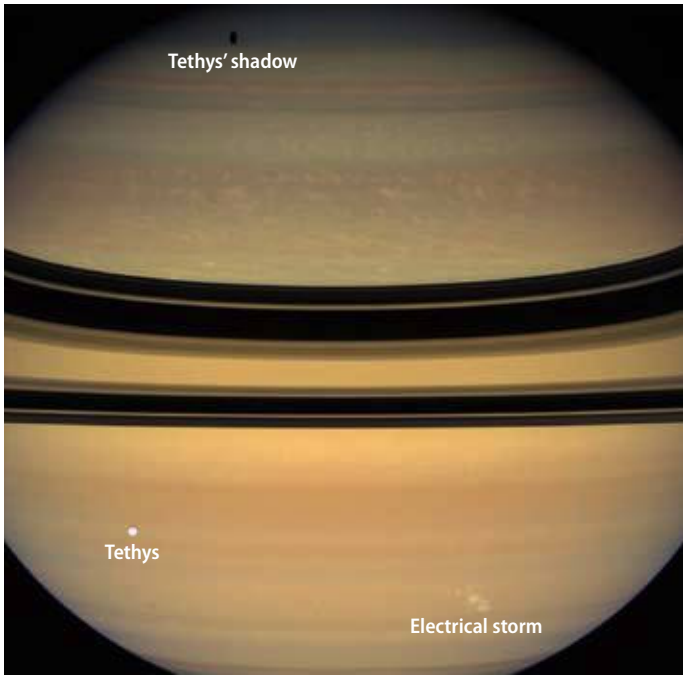

∧ Storm alley. An electrical storm thousands of miles across rages in Saturn's southern latitudes. Cassini first saw it in this December 6 image; the storm continued for at least 5 months. NASA/JPL/SSI

< Big and bright. The storm had changed by March 4, but it still was producing lightning flashes thousands of times stronger than those seen on Earth. NASA/JPL/SSI

Intense storm triggers Saturn lightning

It's unlikely your family pet would enjoy a visit to Saturn. A powerful electrical storm — featuring lightning bolts 10,000 times stronger than those seen on Earth — has raged on the ringed planet for at least 5 months. It ranks as the longest continually monitored storm seen by NASA's Cassini spacecraft.

Cassini initially observed the storm November 27, when instruments detected radio waves produced by the intense lightning flashes. The craft followed up December 6 with images of the storm. The tempest lies in Saturn's "storm alley," a region near 35° south latitude where previous storms fired up.

"The electrostatic radio outbursts have waxed and waned in intensity for 5 months now," said Georg Fischer, a member of the radio and plasma wave science team at the University of Iowa, Iowa City, in late April. "We saw similar storms in 2004 and 2006 that each lasted for nearly a month," he added, "but this storm is longer-lived by far. And it appeared after nearly 2 years, during which we did not detect any electrical storm activity from Saturn."

Although Saturn's electrical storms resemble those on Earth, they occur on a much bigger scale. On Saturn, storms typically have diameters measured in thousands of miles, and the radio signals produced are thousands of times stronger than those produced by terrestrial storms. The radio pulses given off by the current Saturn storm last about 0.1 second and repeat every few seconds. — **RICHARD TALCOTT**

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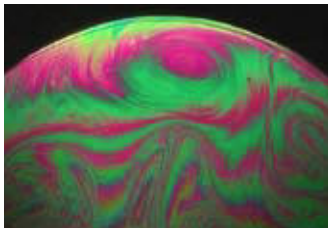
25 Small galaxies weigh plenty

26 India goes to the Moon



Soapy swirl. Researchers at the University of Bordeaux, France, found that stormlike structures naturally form in heated soap bubbles. Hamid Kellay/Univ. of Bordeaux

Soap bubbles hint at stormy processes

Experiments with hemispherical soap bubbles by physicists at the University of Bordeaux in France produce ministorms resembling Jupiter's Great Red Spot and earthly hurricanes. The similarity is more than skin deep, says lead researcher Hamid Kellay.

The half-bubbles are up to 3.9 inches (10 centimeters) wide, heated at the base (effectively their equators), and imaged. Variations in the soap film's thickness create the colors. The heat difference between the bubble's warm equator and cool pole sets up turbulence that sometimes manifests itself as a long-lived swirl.

The use of half-bubbles provides a better glimpse of fluid turbulence than previous efforts, Kellay says. — **FRANCIS REDDY**

Extended arms. Young stars form surprisingly far from the hub of spiral galaxy M83. In this composite image, hydrogen gas appears red and traces young stellar clusters (shown in blue and green). NASA/JPL-Caltech/VLA/MPIA

Stars born in the boondocks

Ask most astronomers where spiral galaxies create new stars, and you'll hear about massive clouds of gas and dust tracing the galaxies' spiral arms. But new observations of the Southern Pinwheel Galaxy (M83) show star formation occurring much farther from the galaxy's center than anyone thought possible.

Astronomers found stars forming more than 100,000 light-years from M83's center. For comparison, M83's visible disk spans just 40,000 light-years. Researchers discovered distant young star clusters through ultraviolet observations made with NASA's Galaxy Evolution Explorer (GALEX) spacecraft. The clusters congregate in M83's so-called extended arms.

Astronomers thought such outlying regions would have a density too low to trigger star formation. "It is absolutely stunning that we find such an enormous number of young stars up to 140,000 light-years from the center of M83," says Frank Bigiel of the Max Planck Institute for Astronomy in Germany, who led the GALEX team.

To better understand how stars could form so far out, the team combined the GALEX data with ground-based radio observations made with the Very Large Array near Socorro, New Mexico. The radio data traces the distribution of hydrogen gas, the raw ingredient for stars. The ultraviolet and radio observations matched almost perfectly.

The astronomers speculate that these distant stars could have formed under conditions similar to those of the early universe, before much dust and significant amounts of heavy elements existed. If so, M83's young stars could provide scientists with a glimpse of how early star generations formed. — **R. T.**

QUICK TAKES

10 NEW PLANETS

Using robotic telescopes in South Africa and the Canary Islands, an international collaboration known as the Wide Area Search for Planets has discovered 10 exoplanets.

MONSTER DUNES

Low gravity and thin air let martian sand grains bounce 100 times farther than earthly ones. This is why martian sand dunes dwarf Earth's — and may explain the origin of Mars' famous dust storms.

HAWKING BACKS NASA

Stephen Hawking backed NASA's plan for a human return to the Moon in 2020 and Mars shots after that in an April 21 speech at the space agency.

WELCOME ABOARD

Austria announced April 24 that it would join the European Southern Observatory (ESO) July 1. ESO's facilities include the Very Large Telescope at Paranal Observatory in northern Chile.

"ARTHRITIC" ROVER ARM

On April 14, the troublesome tool-carrying arm of Mars rover Opportunity seized up. Loss of the arm's movement would be a serious blow to the 4-year-old mission, scientists say.

ULTIMATE IR MAP

United Kingdom astronomers have produced the most sensitive infrared map of the distant universe, containing more than 100,000 galaxies in an area four times that of the Full Moon.

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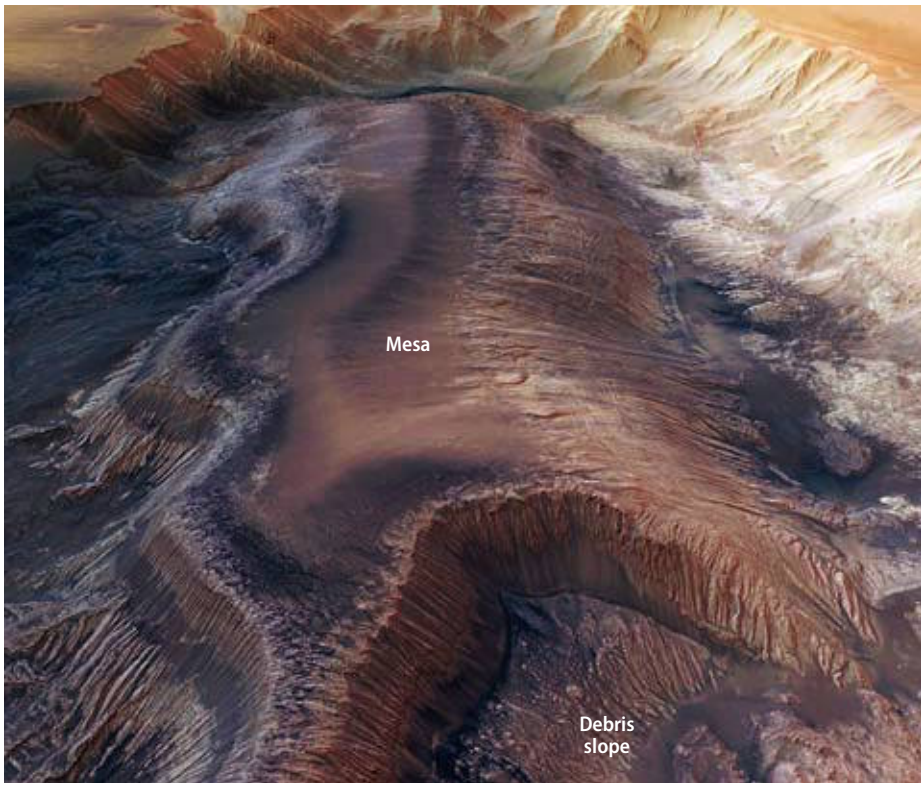
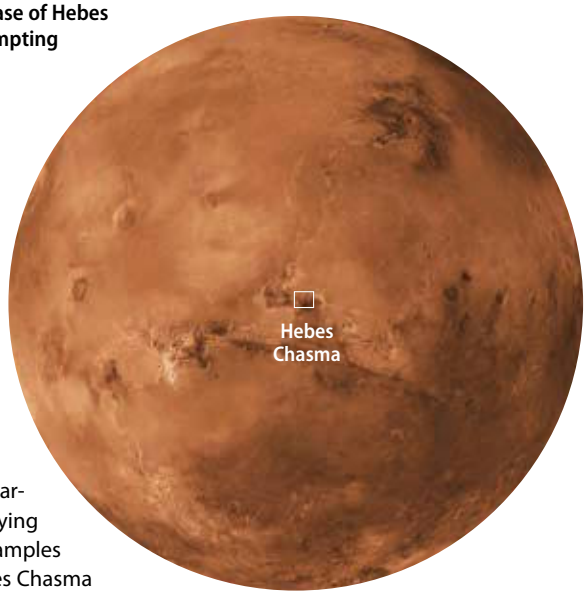


ESA/DLR/FU Berlin (G. Neukum); Mars globe: NASA/World Wind

Mars mesa. Aprons of debris at the base of Hebes Chasma's flat-topped ridge make a tempting site for future rovers.

Is there a rover in Hebes Chasma's future?

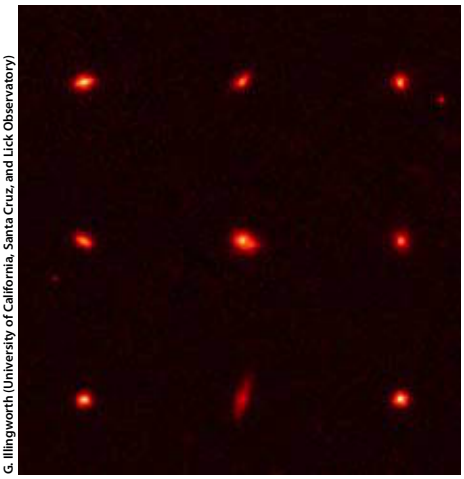


On March 28, the European Space Agency released high-resolution Mars Express views of a gouge on Mars known as Hebes Chasma, one part of the Red Planet's vast Valles Marineris canyon system. Scientists studying a future mission to collect martian samples and return them to Earth place Hebes Chasma on their short list of target sites.

Hebes Chasma (located at 1° south, 282° east) is an enclosed trough nearly 5 miles (8 kilometers) deep. Its steep flanks show branching cuts, small veins of rock, and avalanche debris. A mesa nearly as tall as the canyon is deep rises from the depression's floor. Gully-type landforms on the mesa's sides suggest water erosion.

Scientists at the Center for Mars Exploration at NASA's Ames Research Center in California think that, billions of years ago, closed canyons like Hebes Chasma could have trapped any water flowing through Valles Marineris. Layered deposits exposed in the mesa's walls might include lake sediments that preserve organic chemicals — maybe even fossils.

A good site for a future mission might be the area where Hebes Chasma's floor meets the mesa's debris slope, geologists suggest. This would give a rover access to a variety of rocks that had fallen from the walls' layered formations. — **F. R.**



NASA/ESA/P. van Dokkum (Yale University)/M. Franx (Leiden University)/G. Illingworth (University of California, Santa Cruz, and Lick Observatory)

Small but heavy. **Each of these nine galaxies measures about 5,000 light-years across yet weighs a whopping 200 billion solar masses. The young objects lie some 11 billion light-years from Earth.**

Small galaxies weigh plenty

Imagine a galaxy weighing as much as the Milky Way but having a diameter just 5 percent as large. As difficult as those statistics may be to believe, astronomers have found nine such galaxies in the distant universe.

A team of astronomers led by Pieter van Dokkum of Yale University studied the galaxies with the orbiting Hubble Space Telescope and the 10-meter Keck Telescope on Mauna Kea, Hawaii — the only telescopes able to measure the galaxies' small sizes. Each of the nine galaxies weighs approximately 200 billion times what the Sun does, yet they span a mere 5,000 light-years. In contrast, the Milky Way packs a similar amount of mass into a disk about 100,000 light-years across.

The galaxies lie some 11 billion light-years from Earth, so we see them as they were less than 3 billion years after the Big Bang. "Seeing the compact sizes of these galaxies is a puzzle," says van Dokkum. "No massive galaxy at this distance has even been observed to be so compact, and it is not yet clear how one of these would build itself up to be the size of the galaxies we see today." He thinks half of such distant, heavy galaxies might be this tiny.

Collisions with other galaxies offer one way for compact galaxies to grow, but van Dokkum suspects collisions can't provide the whole answer. The astronomers published their findings in the April 10 issue of *The Astrophysical Journal Letters*. — **R. T.**

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India goes to the Moon

India has delayed the launch of its ambitious Moon probe, Chandrayaan-1. Originally scheduled for an April launch, mission planners now expect it to fly this summer. The probe will launch from the Satish Dhawan Space Center in Sriharikota, which lies on India's southeast coast.

The Chandrayaan-1 orbiter will carry five instruments from India and six from other countries, including the United States. The instruments range from cameras and spectrometers to a mineral mapper and a synthetic aperture radar.

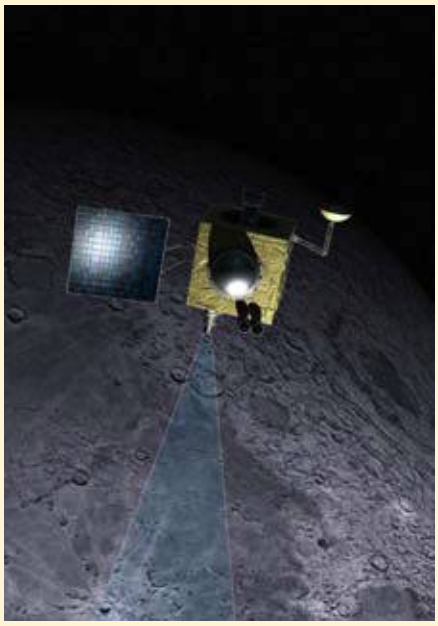
The platform's availability proved convenient for NASA planners, who responded to renewed White House interest in the Moon and beyond by developing the mineral mapping imaging systems. These will complement observations from Europe's Smart-1 probe as well as those from Japan, China, and future U.S. missions.

The probe's name comes from Sanskrit, the ancient common tongue of much of India (as Latin was in Europe), and it means "Moon craft." But its mission is to make India a player in the future of space technology, not just the source of immigrant engineers to other countries and their space programs.

With this mission, India will join Japan and China as major players in lunar exploration. The reasons for targeting the Moon include both prestige and practical benefits. Another big factor is the recent development of rocket and spacecraft technologies that makes such missions possible at a reasonable price and with a reasonable chance of success.

And those aren't the only reasons. A successful Chandrayaan-1 mission will give technological credibility to India's aerospace industry. (Not coincidentally, this was one of the top hidden motivations behind the original "space race" between the United States and the Soviet Union 50 years ago.)

To first get Chandrayaan-1 to the Moon and then to lower its lunar orbit for science surveys will require precision tracking, accurate targeting, and near-perfect rocket firings. Such capabilities, once proved in space, will testify to similar capabilities with military missile systems — enhancing their deterrent value (and the export sales value) of Indian weapons.



Moon shot. Chandrayaan-1, scheduled for launch this summer, maps the Moon's surface in this artist's concept. ISRO

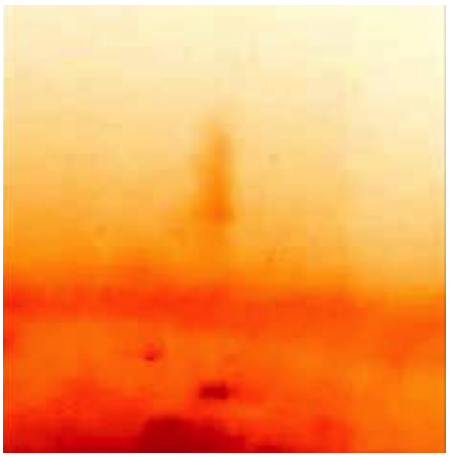
Chandrayaan-1's trajectory to the Moon will be cautious, befitting the country's first mission beyond geosynchronous orbit. To derive maximum benefit from flight plans already developed and tested for reaching geosynchronous orbit, India will launch the probe into a transfer orbit just as if it were a 24-hour communications satellite. Instead of firing a rocket to circularize the orbit at an operational altitude of 22,300 miles (35,900 kilometers), Chandrayaan-1 will make a series of burns near perigee. This will raise the probe's apogee until it gets onto a 5-day translunar course.

Once it reaches the Moon, Chandrayaan-1 will reverse the series of steps, starting in an orbit about 620 miles (1,000 km) high and gradually tightening the path until it reaches an observation altitude of about 60 miles (100 km). There, it will spend at least 2 years measuring the lunar surface.

The mission also may include a deployable surface impactor to test navigational capabilities leading to a planned soft landing of a rover in 2012 or so. India also is considering a mission to Mars, and has other plans to complement, supplement, and eventually move beyond research already done by other nations.

The solar system is big enough for any number of spacefaring nations to carve unique niches. Chandrayaan-1 could become India's impressive first slice.

— JAMES OBERG



Hot jet. **Hinode's EIS instrument captured a bullet of gas arcing above the Sun's north polar region.** Jian Sun/MSSL/UCL/JAXA/NAOJ/NASA/ESA/NSC

Hinode captures solar "fountains"

Jets of hot gas blast at high speed into the Sun's outer atmosphere, the corona, every few minutes. A team of scientists using data from the Japanese solar observatory Hinode claim that immense magnetic structures threading through the solar atmosphere drive these "fountains."

Team leader Michelle Murray from the Mullard Space Science Laboratory in London presented the group's findings April 2 at the Royal Astronomical Society's National Astronomy Meeting in Belfast. Hinode imaged the fountains using its Extreme Ultraviolet Imaging Spectrometer (EIS), built by a Mullard-led consortium.

"EIS has observed the Sun's fountains in unprecedented detail, and it has enabled us to narrow down the fountains' origins for the first time," says team member Deb Baker. "We have also been able to find what drives the fountains by using computer experiments to replicate solar conditions."

Continual rearrangements of the magnetic field create intermittent solar fountains, the team found. Rising pressure at surface magnetic fields causes the jets to shoot into the solar atmosphere. Once the pressure drops, the gases fall back to the surface.

"The computer experiments demonstrate that when a new section of magnetic field pushes through the solar surface, it generates a continual cycle of fountains," Murray explains. Because new magnetic fields constantly emerge across the Sun's surface, she says, the results can explain the multitude of fountains Hinode observes. — **F. R.**

BRIEFCASE

A pitch from space

On April 16, astronaut Garrett Reisman — onboard the International Space Station — threw out the ceremonial first pitch of the New York Yankees baseball game. Although the pitch was a bit high (by 220 miles or so), it worked for the Yankees, who defeated the Boston Red Sox that night, 15–9. — R. T.

GLOBE at Night 2008

Participants in the international GLOBE at Night project made 6,838 measurements of night-sky brightness from February 25 to March 8. The citizen scientists gauged light pollution by counting the number of stars visible in the constellation Orion. — D. P.

Aligned aurorae

Some of the light from Earth's aurorae is polarized, that is, it shares a common orientation, say scientists observing in Norway. Previously, scientists thought collisions among light-emitting molecules would prevent such alignment. — F. R.

25 years ago in *Astronomy*

August 1983

In August 1983, Francis Reddy (now a senior editor) examined Earth's magnetosphere and how scientists are studying it in "Polar lights."

The magnetosphere is the region where our planet's magnetic field catches and controls the movement of electrically charged particles from the solar wind. Since the launch of Explorer 1 in 1958, astronomers have been studying this invisible shield.

Back then, the latest magnetospheric probes were Dynamics Explorers 1 and 2. The joint NASA mission launched August 3, 1981, and returned about 90,000 images to Earth in the first year. DE 2 returned to Earth in February 1983. DE 1 remained in orbit until 1991.

August 1998

10 years ago in *Astronomy*

In August 1998, *Astronomy* celebrated its 25th birthday with a collector's edition. The issue explored the top 25 discoveries of the previous 25 years.

Rex Graham highlighted these additions in "25 new citizens of the cosmos." Included in the list were discoveries relating to extrasolar planets, black holes, the Eagle Nebula, and more.

"The years have given proportion to many of the discoveries made since *Astronomy* was founded," wrote Graham. "During that time, astronomical knowledge has exploded — we could have made a list of 25,000 'new citizens of the universe.'" — **MEGAN MCCHAIN**

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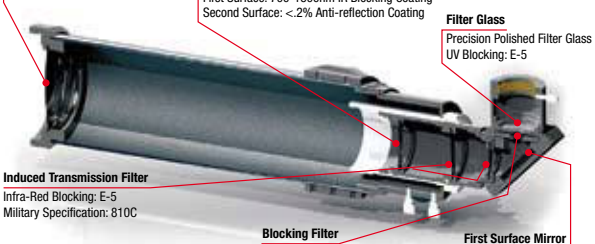

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Is there an end to cosmology?

In the far future, astronomers will have only one galaxy to study, and all evidence for the Big Bang will be lost. **by Abraham Loeb**

Each January, when the President of the United States delivers the State of the Union address, I find myself imagining a brief statement about the bigger picture. To put it bluntly, the state of our universe is not looking good for future observers.

Over the past decade, cosmologists have reached their best-ever observational understanding of the universe. First, thanks to the finite speed of light, scientists actually can observe the universe as it looked in the past. Light we observe today from a distant galaxy must have been emitted at an earlier time in order to reach us now. So, by looking deeper into space, astronomers see the cosmos as it looked at earlier times.

Since the 1920s, astronomers have known that all distant galaxies are moving away from us due to the expansion of space. By measuring ever-farther distances, astronomers can establish how the rate of expansion changed during the universe's history.

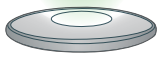
Because gravity acts to bring matter together, we might naturally expect the expansion slowed down with time. But did it? In the past 2 decades, astronomers worked to test this conclusion through telescopic observation.

Abraham Loeb, *a world leader in theoretical cosmology, is the director of the Institute for Theory and Computation at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.*

Light a standard candle

If you know that all streetlights have, say, 100-watt bulbs, you can determine the distance to any streetlight you see just by measuring how bright its light appears. The bulb's energy spreads out spherically in a manner that increases with the square of the distance to the source. Because the radiation we see from a bulb dilutes with the distance squared, we can calculate its distance.

The accelerating universe makes cosmology a fleeting scientific endeavor.



Fortunately for astronomers, a particular type of exploding star — type Ia supernovae — provides a standardized "light bulb" that can be seen to the edge of the observable universe. A decade ago, two groups of astronomers inferred distances to many supernovae. They discovered that, contrary to expectations, cosmic expansion has been speeding up for the past 5 billion years.

Until the supernova studies, physicists had only upper limits for the mass or energy density of empty space. Intuition suggests this value should be zero, but it isn't necessarily so.

Einstein's 1915 theory of relativity says that if the vacuum's mass density is more than half the universe's matter density, then space has a negative pressure. If the expanding universe's vacuum energy remains constant (as Einstein originally thought), eventually this condition will be met. That is, there will be a time when the universe's matter density drops to half the vacuum's mass density. The result: accelerating expansion that pushes galaxies away from each other at an ever increasing rate.

Out of sight

If the universe is dominated by a cosmological constant of the sort Einstein envisioned, then, as the universe ages by another 10 times, the accelerated expansion will push all galaxies outside our immediate vicinity beyond the observable universe. In 2002, I showed that all galaxies beyond redshift 1.8 (about 10 billion light-years away) already are outside our horizon.

These galaxies emitted the light we see from them a long time ago, when the universe was one-third its present 13.7-billion-year age. What we see does not represent their current state. If their light contains some message from a distant

civilization, any reply we make will never reach them. Within a finite time, the accelerated expansion of space moves any distant galaxy away from us at a speed that exceeds even that of light.

The situation is similar to watching a friend cross a black hole's event horizon. From a distance, we would see our adventurous friend's image heading toward a black hole, getting fainter, and eventually freezing just outside the horizon. Beyond that moment, classical general relativity offers no way to retrieve additional information.

Likewise, the image of each galaxy will freeze sometime in the future. We will never be able to study the evolution of a galaxy beyond some finite age in its own frame of reference. The more distant a galaxy is, the earlier its image will freeze, and the less information will be available to us about the way it ages.

Of course, systems held together by a force stronger than the cosmological constant do not participate in the cosmic expansion. This includes electrons bound to atoms by the electromagnetic force, planets bound to the Sun, and galaxies held by a gravitational pull stronger than cosmic repulsion.

So, which galaxies will remain in sight? I worked with Ken Nagamine, now at the University of California at San Diego, to simulate the future evolution of all galaxies within 100 million light-years of the Milky Way. Our simulation, which was based on data on the local distribution of galaxies, indicated that no galaxy more than 3 million light-years away will remain in our horizon. All will be pushed out of our view as the cosmos expands.

The Andromeda Galaxy (M31) and the Milky Way are the only two large galaxies within this range — and they happen to be on a collision course. Harvard's T. J. Cox and I showed that the two galaxies will merge to make a new one, which I call Milkomeda (see "Our galaxy's date with destruction," June 2008). Ultimately, Milkomeda is the only galaxy that will remain visible to astronomers.

Suppose some future cataclysm destroys all scientific archives. Could future astronomers, who are able to study only Milkomeda, be able to reveal it originated from the Big Bang? No, wrote Lawrence M. Krauss (Case Western Reserve University, Cleveland) and Robert J. Scherrer (Vanderbilt University, Nashville) in an award-winning essay last year (see arxiv.org/abs/0704.0221).

To future astronomers, the universe will appear to be static and occupied by only one galaxy, the merged remnant of the Milky Way and the Andromeda Galaxy known as Milkomeda. The accelerated expansion of the cosmos will erase all evidence it arose in a Big Bang. *Astronomy:* Theo Cobb and Chuck Braasch

The accelerating universe makes the study of cosmology a transient episode in our long-term scientific endeavor. We had better observe the universe in the next tens of billions of years and document our findings for the benefit of future scientists who won't be able to do so. Perhaps funding agencies should take notice and allocate funds for cosmology now. One day, such studies be impossible.

Once that happens, any presidential State of the Union address will be fully justified in ignoring the universe at large.

If you like monster telescopes, dark energy, and exo-Earths, you'll love what astronomers are planning for the next decades.

by Francis Reddy

Where will astronomy

By the time *Astronomy* hits 70, will scientists understand the source of dark energy? Will they be studying dark matter in the laboratory? Will astronomers have found another Earth — perhaps with signs of life — in the habitable zone of a distant sun? As far as astronomers can tell, these big stories of the past few decades will hold center stage for years to come.

Looking 35 years down the road is bound to be hit and miss. Ambitious plans for manned lunar missions or exciting planetary probes may run aground of uncertain future budgets.

Yet, answers to some of the big cosmic questions could come sooner rather than later. "Serendipity may still lead to the greatest advances from the instruments now being planned or built," says Martin Rees, the United Kingdom's Astronomer Royal. And past experience with major astronomical facilities suggests those in the planning stages will play important roles several decades forward. "The timescale for big projects is very long — depressingly so," he notes.

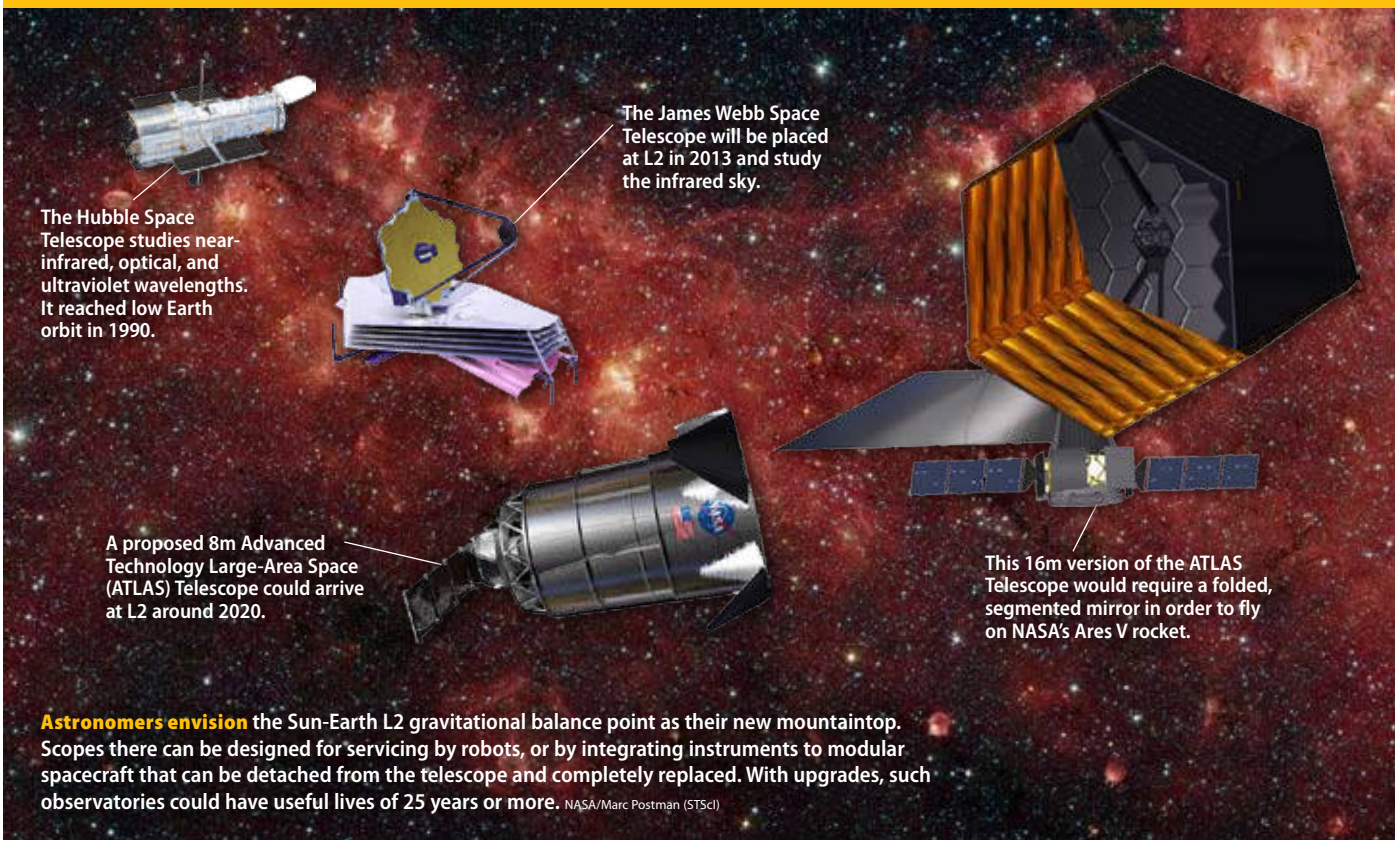
The reason: Modest increases in resolution or sensitivity don't buy astronomers much in the way of breakthrough

Francis Reddy *is a senior editor of* Astronomy.

be in 35 years?

When complete in 2016, the Giant Magellan Telescope in Chile (left) will be a leading optical and infrared observatory. *Background:* The Deep Lens Survey imaged stars and galaxies in Cancer. Such views will be routine as new, fast survey scopes begin work. *Top right*: Deep images will give astronomers their best look at the gravitational effects of dark matter. Montage: *Astronomy*: Roen Kelly; Telescope: Carnegie Observatories; Background and top right: LSST Corporation/Deep Lens Survey/UC Davis/NOAO

A growing fleet of space telescopes


The Hubble Space Telescope studies near-infrared, optical, and ultraviolet wavelengths. It reached low Earth orbit in 1990.
The James Webb Space Telescope will be placed at L2 in 2013 and study the infrared sky.
A proposed 8m Advanced Technology Large-Area Space (ATLAS) Telescope could arrive at L2 around 2020.
This 16m version of the ATLAS Telescope would require a folded, segmented mirror in order to fly on NASA's Ares V rocket.

Astronomers envision the Sun-Earth L2 gravitational balance point as their new mountaintop. Scopes there can be designed for servicing by robots, or by integrating instruments to modular spacecraft that can be detached from the telescope and completely replaced. With upgrades, such observatories could have useful lives of 25 years or more. NASA/Marc Postman (STScI)

science. They need jumps of a factor of 10 or more to really raise the bar. Matt Mountain, director of the Space Telescope Science Institute, quotes the late Wal-Mart entrepreneur Sam Walton: "Incrementalism is innovation's worst enemy. We don't want continuous improvement, we want radical change."

Small scopes, big returns

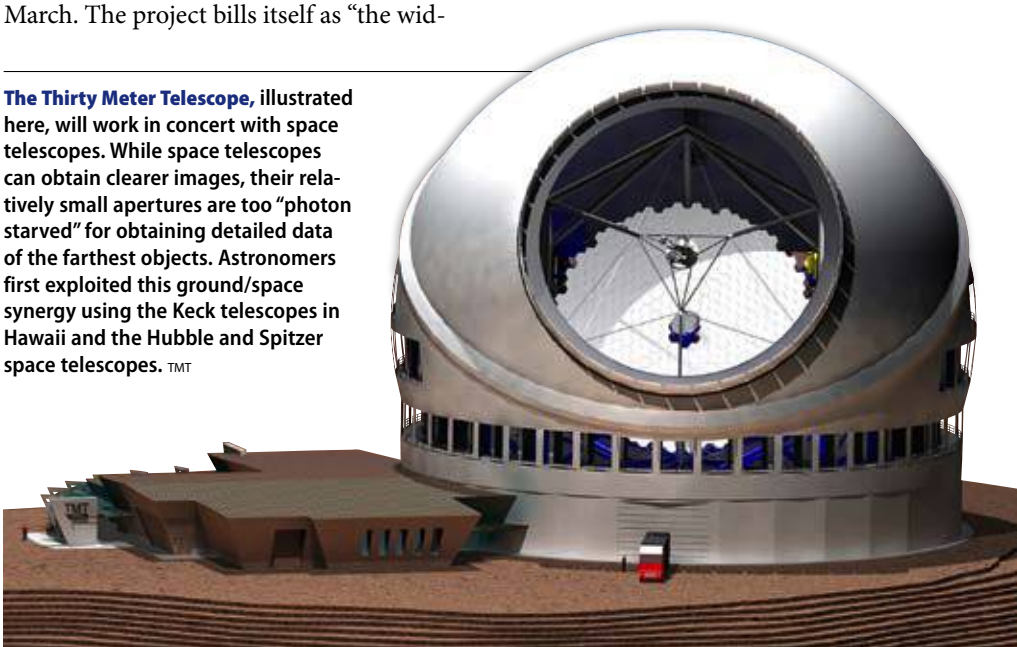
Survey projects that couple modest telescopes with state-of-the-art imaging and data-processing systems leapfrog the science by leveraging rapidly changing technology. The tremendous success of the Sloan Digital Sky Survey, which uses a single 2.5-meter scope, shows that small apertures and high-tech can produce superb "discovery factories."

Two projects in the works will be Sloan's successors. The first is the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS), developed by the University of Hawaii's Institute for Astronomy. The Pan-STARRS 1 prototype is a 1.8m scope with a 3° field of view coupled to a 1.4-billion-pixel digital camera. It already has begun a 3.5-year sky survey.

By 2012, Pan-STARRS astronomers expect to quadruple this setup. Four identical optical systems will observe the same sky area at the same time. In final form, Pan-STARRS will image the entire Hawaiian sky 3 times every month.

A more ambitious project, the Large Synoptic Survey Telescope (LSST), expects "first light" by 2014. The University of Arizona's Steward Observatory Mirror Lab began casting the LSST's mirrors, which include an 8.4m primary, in March. The project bills itself as "the widest, fastest, deepest eye of the new digital age." Armed with a 3.2-billion-pixel camera, LSST will image a 9.6-square-degree field up to 4 times a minute each night. This means the scope will record the entire available sky from its site in the Chilean Andes every 3 nights.

Rapid all-sky imaging will uncover supernovae, potentially hazardous near-Earth asteroids, and distant Kuiper Belt objects. Astronomers with Pan-STARRS



The Thirty Meter Telescope, illustrated here, will work in concert with space telescopes. While space telescopes can obtain clearer images, their relatively small apertures are too "photon starved" for obtaining detailed data of the farthest objects. Astronomers first exploited this ground/space synergy using the Keck telescopes in Hawaii and the Hubble and Spitzer space telescopes. TMT

plan to give the Andromeda Galaxy (M31) special attention by building up the deepest-ever survey of our neighboring spiral. Astronomers expect LSST's superb images will allow them to use the light-bending effect of large masses to trace billions of remote galaxies and map out how dark matter — a mystery substance revealed only by its gravity — distorts their shapes.

From planets to cosmology

Distant solar systems and planet-forming dust disks are among today's hottest astronomical topics. Extrapolating from the nearly 300 planets known, astronomers say our galaxy contains at least a billion worlds. NASA's Kepler mission, scheduled for launch in 2009, is the U.S. space agency's first mission capable of finding Earth-sized planets around other stars.

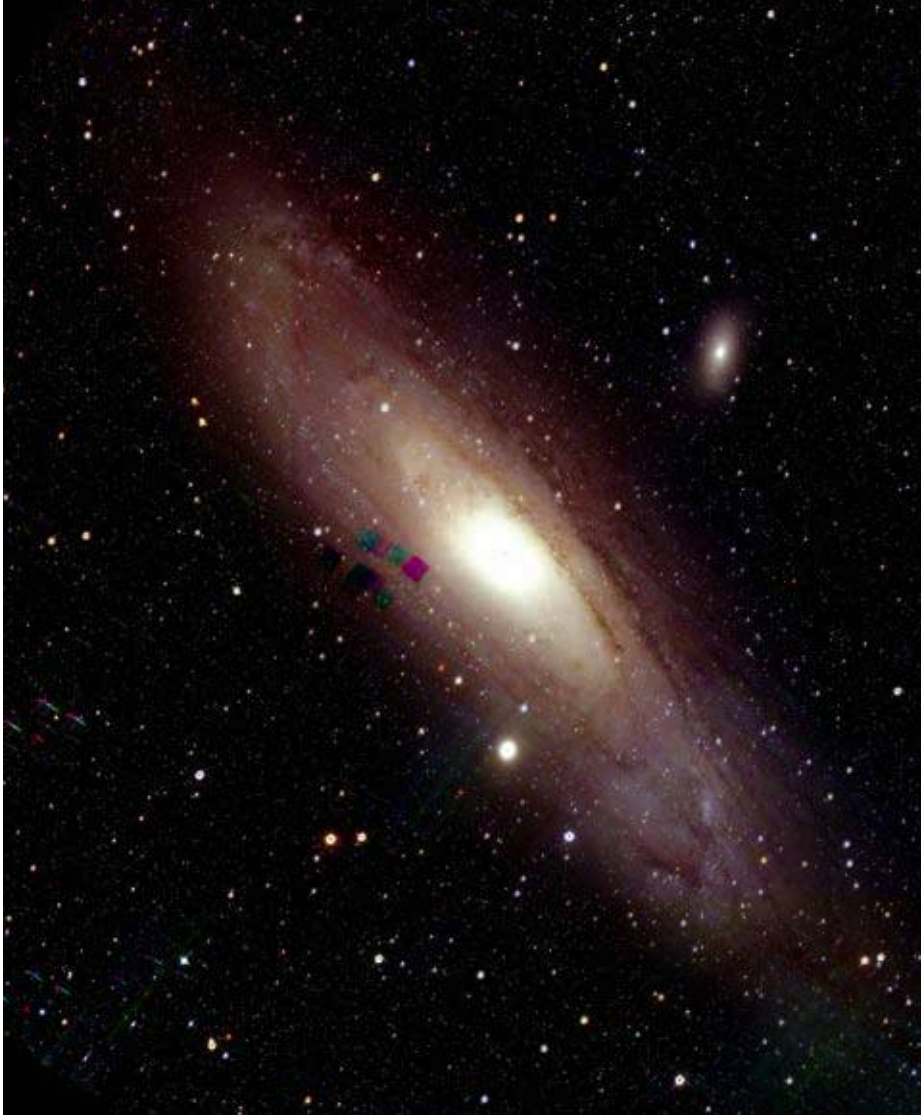
Except for the time Kepler takes to downlink its data, the spacecraft will continuously point its 1.4m telescope at a single field in Cygnus and Lyra for more than 3 years. Kepler will monitor 100,000 main-sequence stars for brief dips in brightness caused by planets crossing their disks. The mission will pave the way for later planet-hunters like NASA's SIM PlanetQuest and the European Space Agency's Gaia.

The Joint Dark Energy Mission (JDEM), a partnership between NASA and the U.S. Department of Energy, is a survey dealing with the other end of the cosmic scale. Three concepts are under consideration, but because they'll use telescopes with apertures smaller than 2 meters, whichever one NASA selects will reach space relatively quickly. The mission's goal: Study many type Ia supernovae in galaxies near and far so scientists can hone their understanding of dark energy, the mysterious force that's accelerating the universe's expansion.

"Dark matter and dark energy are the outstanding problems in cosmology today," says Caltech's Richard Ellis. He'd like to think that, in 35 years, mapping surveys will give astronomers a much better idea of how dark matter behaves, and he hopes physics experiments, like the Large Hadron Collider now starting up in Switzerland, will yield a clearer understanding of its nature.

Likewise, Ellis feels we probably will know much about how dark energy behaves in governing cosmic expansion, but he's not so sure astronomers will have made much progress in understanding its origin. "I suspect we need some form of breakthrough, just as dark energy emerged as a surprise in the late 1990s from the supernovae programs."

Robert Millis, director of Lowell Observatory in Flagstaff, Arizona, puts it more bluntly: "The true nature of dark energy will remain a mystery — or, if it doesn't, somebody will have earned a Nobel Prize."



Pan-STARRS/Univ. of Hawaii

The Andromeda Galaxy (M31) was one of the first targets of the prototype 1.8m Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) scope. The stripes and colored squares in this Gigapixel Camera composite are image artifacts that improved calibration data will eliminate.

The coming megascopes

Space has significant advantages for telescopes designed to see ultraviolet (UV), visible light, and near-infrared wavelengths. There's no air to absorb UV, distort images, or radiate heat that competes with astronomical sources.

But with a new generation of adaptive optics — technology that warps telescope mirrors to compensate for atmospheric turbulence — and filters that partially reduce the sky's infrared brightness, large telescopes on the ground can compete. "Ground-based telescopes inevitably will win at optical and near-infrared wavelengths because of their larger apertures," Ellis says. "I see space telescopes moving to occupy only those unique wavelengths where the atmosphere is totally opaque — X-ray and mid- to far-infrared, in particular."

The Giant Magellan Telescope (GMT) will be the next major ground-based facility. Developed in partnership with the Carnegie Institution of Washington, Harvard University, Massachusetts Institute of Technology, and others, GMT is expected to see first light in 2016. Its seven 8.4m mirrors will combine to create the resolution of a telescope with a 24.5m aperture. As an added bonus, GMT will feature the most advanced adaptive optics system.

Bigger scopes, sharper images

Here's how a galaxy 7 billion light-years away would look to an 8m telescope on Earth.

The Hubble Space Telescope, with 0.1" resolution, would see the same galaxy like this.

The Thirty Meter Telescope, with 0.008" resolution under ideal conditions with adaptive optics, would provide this view. Marc Postman (STScI) and Richard Ellis (Caltech)

Fast on GMT's heels will come the Thirty Meter Telescope (TMT), now being developed by Caltech and the University of California. This wide-field scope will sport a 492-segment, 30m-diameter primary mirror. Planners expect to begin observing with this monster by late 2016. TMT's enormous light-gathering power will allow astronomers to use faint, distant galaxies as probes to detect intergalactic gas, which will provide insight into the first generations of stars in early galaxies.

"Galaxy evolution is a topic of great excitement at the moment," Ellis says. "The final frontier represents understanding the most distant and, hence, earliest objects. What happens in the first billion years of history affects the subsequent growth of galaxies."

Ellis thinks the future holds a change. Astronomers will spend less time simply charting these objects and begin discovering what's going on within them. The subject will move to a new level of detail — how galaxies develop their spin, how central bulges and bars form in spirals, and how black holes and star formation interact.

An 8-meter space telescope isn't quite big enough to do the science astronomers want to do.

With LSST and TMT, two additional facilities round out Ellis' list of the top ground-based observatories during the next 30 years. The Atacama Large Millimeter Array (ALMA), located in Chile's Atacama Desert, should begin observations in 2012. This powerful interferometer is designed to explore radio- and far-infrared wavelengths.

What scientists consider the next logical step in radio astronomy after ALMA is the Square Kilometer Array (SKA), to be sited either in Australia or South Africa in 2020. As its name suggests, this array of some 350 antennae will provide 1 million square meters (621 square miles) of signal-collecting area. That's 100 times greater area than the 27-dish Very Large Array in New Mexico.

Science for SKA will range from dark energy to exoplanets. Viewed from 500 light-years away, our solar system would be about 1" across. That's 1,000 times larger that SKA's resolution at its highest frequencies. Astronomers will be able to search the dust in habitable zones around other stars for gaps made by earthlike planets. SKA even will be sensitive enough to detect signals of comparable strength to TV transmitters on planets orbiting the closest stars.

In the 20th century, Ellis says, astronomy's great triumph was understanding stellar evolution by making detailed measurements of stars in various phases of their life cycles. "We can expect to place both galaxy evolution and the formation of extrasolar planets into a similar level of understanding via our future facilities."

What about space?

After JDEM, NASA will follow up with its biggest-aperture observatory since Hubble: the 6.5m James Webb Space Telescope (JWST). After a 3-month voyage, JWST will reach its destination, 932,000 miles (1.5 million km) behind Earth at a place called Sun-Earth L2, one of several quasi-stable points where the gravity of the Sun and Earth balance. There, away from the heat of a nearby planet, JWST can reach low temperatures — necessary to carry out its infrared studies — without coolant. Although NASA originally considered JWST a mission that would not be serviceable, that thinking has begun to change.

Astronomers view Sun-Earth L2 as a new mountaintop: Construct an observatory there, then service and upgrade it as needed for a couple of decades. In the last 10 years, mission planners have uncovered new, low-energy transfer orbits between Earth and Sun-Earth L2. This makes it feasible, with little fuel, to retrieve a craft from L2, upgrade it, and send it back up the "mountain." Alternatively, a telescope could be designed with a detachable spacecraft and instrument platform. Just send out a fresh spacecraft with upgraded instruments, dock it to the telescope, and return the old one.

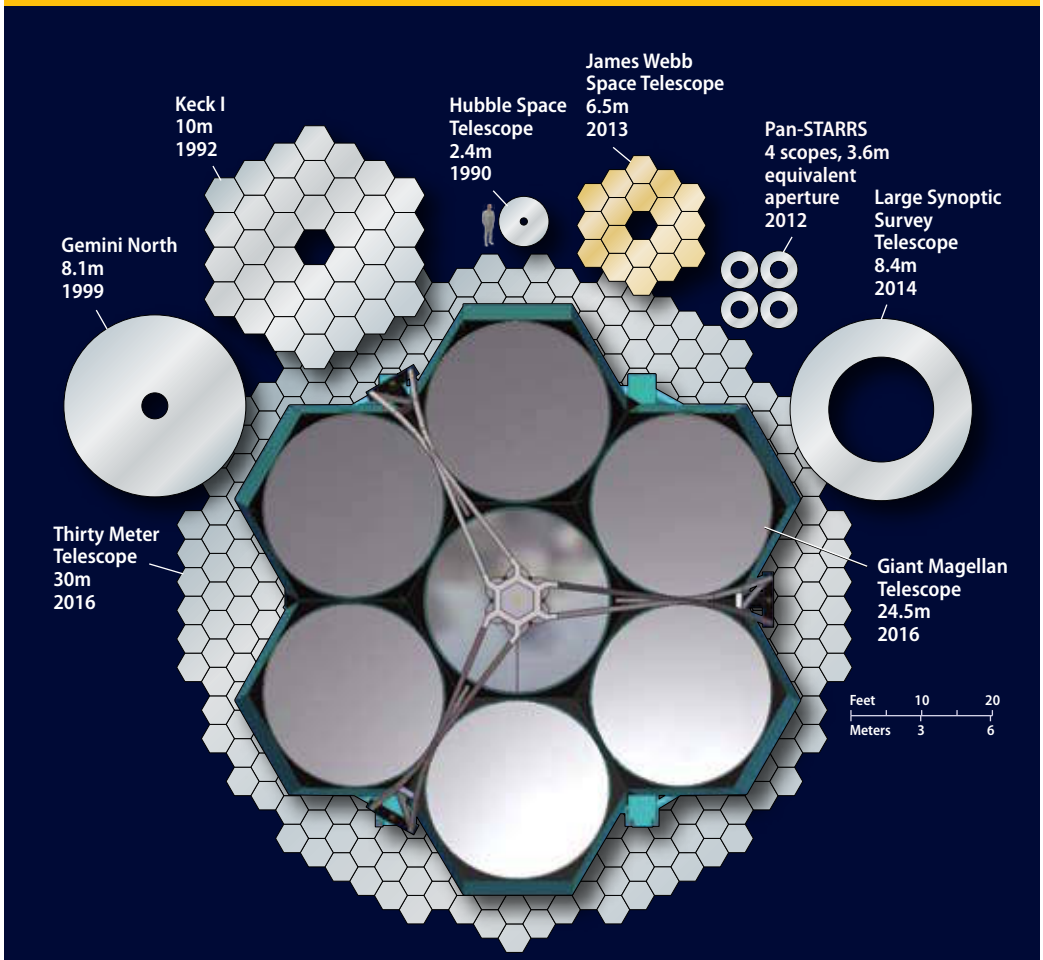
How this will play out with JWST is unclear because it wasn't designed for

servicing. But Marc Postman and Kenneth Sembach at the Space Telescope Science Institute in Baltimore are studying the possibility of building a new space telescope designed to study optical, ultraviolet, and infrared wavelengths. It would be a true successor to Hubble.

Their Advanced Technology Large-Aperture Space (ATLAS) Telescope would launch on NASA's planned Ares V heavy-lift rocket, expected to be available in 2019. Although this enormous booster is intended to support human missions to the Moon, the Ares V can place twice as much payload at Sun-Earth L2 as it can deliver to the lunar surface.

That gets astronomers' attention. The question is: What type of project will guarantee them a ride?

Present and future scopes compared



Space- and ground-based telescopes now in the planning stages dwarf today's largest. The full four-telescope Pan-STARRS will begin taking data around 2012. NASA's James Webb Space Telescope, with its gold-coated mirror, is scheduled to fly in 2013. The Large Synoptic Survey Telescope will see first light in 2014. Astronomers expect both the Giant Magellan Telescope, which combines seven 8.4m primary mirrors, and the Thirty Meter Telescope to begin making observations in 2016. *Astronomy*: Rick Johnson

Eight is not enough

The Ares V's payload fairing is wide enough to accommodate a single telescope mirror about 8 meters across, but Postman and Sembach are looking for something more. "Eight meters isn't quite enough to do the things astronomers want to do," Postman says.

For example, Hubble's ability to resolve Sun-like stars 2.5 million light-years away in the Andromeda Galaxy let astronomers work out its assembly history — how it gobbled smaller galaxies to become what we see today. A 16m ATLAS Telescope could perform the same census out to the Coma-Sculptor cloud of galaxies, some 42 million light-years away.

Such a program would dovetail with one of JWST's goals: unraveling stellar populations in extremely distant galaxies. "We will need to understand the detailed evolutionary history of nearby galaxies to make sense of the more distant samples," Postman says.

The ATLAS Telescope also would extend Hubble's exoplanet work. Astronomers have cataloged stars they consider the best candidates for harboring planets capable of developing life. The ATLAS Telescope could explore many of these stars' habitable zones — the band of distances where an earthlike planet's water would be liquid some of the time. Fewer than 10 of these targets lie within Hubble's reach. But more than 4,000 systems, at distances out to 245 light-years, are within a 16m ATLAS Telescope's grasp.

While Postman's study will consider apertures of this size, he knows this will entail the complication of folding the mirror, just as JWST does, in order to pack it into an Ares V. The study group's primary goal is to identify key technologies needed to allow construction, a decade from now, of a telescope much more powerful than Hubble, but no more costly.

In 1982, two astronomers credited with shepherding Hubble's development, John Bahcall and Lyman Spitzer, Jr., wrote that a space telescope would help solve many astronomical puzzles. But they understood its real value lay in discoveries as yet unimagined. They wrote: "The greatest excitement … will come when the pictures returned from the satellite reveal things no one in this generation of astronomers has dreamed of, phenomena that only the next generation will be privileged to understand."

That prediction likely will hold for the next 35 years, too.

Zoom into the Pan-STARRS image of the Andromeda Galaxy at www.Astronomy.com/toc.

Top 10 discoveries of the last 35 years

An overly energetic universe, hundreds of new planets, and twin voyages of discovery highlight 35 years of incredible astronomical breakthroughs.

by Richard Talcott

When *Astronomy* first hit newsstands in summer 1973, scientists thought the universe began with a bang marked by finely tuned initial conditions, and would expand forever at an ever-slowing pace. We now know that a brief period of hyper-expansion rescued the Big Bang theory from the need for fine-tuning, and dark energy — or something like it — is accelerating cosmic expansion.

In 1973, nine planets existed in the solar system and none were known beyond. Now, our system has shrunk to eight but the galaxy's planet count has ballooned into the hundreds. And our solar system's planets now boast more than 150 moons — many as intriguing as the planets they orbit — up from a mere 32 in 1973.

It's been an exhilarating ride for everyone involved, from the professional scientists who made the discoveries to the public that devours the latest findings. *Astronomy*'s editors sifted through all the discoveries to compile this countdown of the top 10.

Richard Talcott *is a senior editor of* Astronomy.

10 Belly up to the bar

Pick up any astronomy book from the 1970s or '80s, and you'll read that the Milky Way is a spiral galaxy. Nothing odd about that — astronomers detected several spiral arms in the 1950s at optical wavelengths. Later, radio observations mapped the details of our galaxy's spiral structure.

Still, the Milky Way kept some secrets. Understanding our galaxy's structure is akin to appreciating the entire Amazon rain forest from within a thick stand of trees. Dust and gas clouds clog the Milky Way's disk, effectively masking what lies beyond. It took time for astronomers to develop techniques to see toward the galaxy's center.

The veil started to lift in the 1990s. Astronomers using the orbiting Compton Gamma-Ray Observatory observed emission from a radioactive isotope of aluminum, which tracks the locations of massive stars. The results suggested the Milky Way's center harbors a central bar.

Confirmation of the Milky Way's status as a barred spiral galaxy came from the Spitzer Space Telescope. Observing in the infrared part of the spectrum, which can penetrate the disk's dust, Spitzer surveyed some 30 million stars toward the galaxy's center.

Spitzer verified the bar's existence and mapped its extent. We now know the bar extends roughly 27,000 light-years and tilts at a 45° angle to a line joining the Sun and the galaxy's center. So, the Milky Way isn't a typical spiral. Instead, our home galaxy sports a long, massive bar that redefines its cosmic nature.

A barred spiral galaxy? It appears the Milky Way belongs to this galaxy class, and is not a normal spiral as astronomers thought in the 1970s. Our galaxy's bar spans about 27,000 light-years, roughly half that of the bar in NGC 1300 seen here. NASA/ESA/The Hubble Heritage Team (STScI/AURA)

9 An attraction of massive proportions

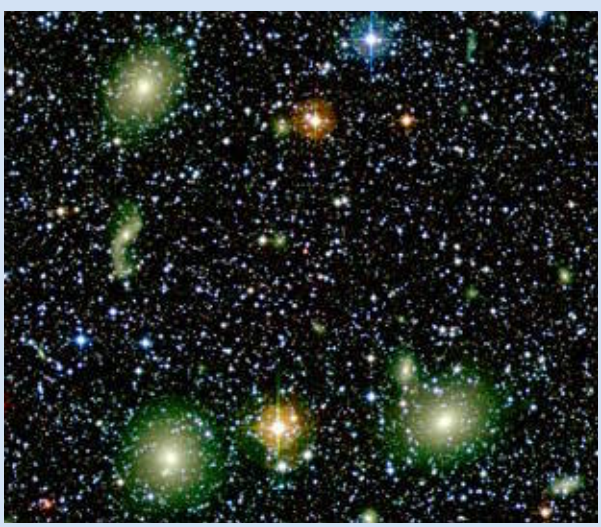
The great British scientist Isaac Newton (1642–1727) developed the law of universal gravitation: Every object exerts an attractive force on every other object proportional to its mass. Yet until the past few decades, no one knew just how strong that attraction could become.

In the mid-1970s, astronomers started to get an inkling. They knew the Local Group of galaxies — dominated by the Milky Way and Andromeda galaxies — were racing toward the Virgo cluster at a million mph (1.6 million km/h). This cluster, a vast collection of up to a thousand galaxies, rules the local universe. It marks the center of the Virgo supercluster, an even larger assembly of galaxy groups and clusters, of which the Local Group is an outlying member.

Observations in the 1970s began to show that even the Virgo supercluster was on the move. By 1986, a team of astronomers, led by Sandra Faber and calling themselves the Seven Samurai, showed we were hurtling at some 13 million mph (22 million km/h) toward a relatively inconspicuous spot in the southern sky. Team member Alan Dressler dubbed the region the Great Attractor, and the name stuck.

Why hadn't astronomers pinned down this object earlier? It lies just 7° from the plane of our galaxy, so it's obscured heavily by dust and gas. The Great Attractor marks the site of a massive supercluster that likely contains up to 100,000 galaxies and lies some 250 million light-years from Earth.

The Great Attractor's center coincides with the Norma galaxy cluster (Abell 3627). Although astronomers knew of this cluster before the Seven Samurai, the Milky Way's interference concealed its size.



The Great Attractor lies about 250 million light-years from Earth, yet its gravity exerts a strong pull on our Local Group of galaxies. The Norma galaxy cluster (Abell 3627) seen here marks the Great Attractor's center. ESO

The ultimate award

Although the Swedish Academy of Sciences awards no Nobel Prize in astronomy, the Nobel Prize for Physics occasionally recognizes outstanding astronomers. Here are the scientists and their accomplishments deemed worthy by the Nobel Committee during the past 35 years. — *R. T.*

1974: Sir Martin Ryle and Anthony Hewish for their pioneering research in radio astrophysics

1978: Arno Penzias and Robert Wilson for their discovery of the cosmic microwave background radiation

1983: Subramanyan Chandrasekhar for his theoretical studies on the structure and evolution of stars; William Fowler for his studies of nuclear reactions important in the formation of chemical elements

1993: Russell Hulse and Joseph Taylor for their discovery of gravitational waves emanating from a binary pulsar

2002: Raymond Davis and Masatoshi Koshiba for their detection of cosmic neutrinos; Riccardo Giacconi for pioneering contributions to astrophysics that led to the discovery of cosmic X-ray sources

2006: John Mather and George Smoot for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation

8 A blast from the recent past

Supernova 1987A heralded a new era for astronomy. For the first time, scientists were able to study a star's explosion from core collapse through the first decades of its remnant's evolution. The new knowledge confirmed many long-held beliefs and refuted several others.

The stellar blast — first seen on Earth before dawn February 24, 1987 — took place in the Milky Way's companion galaxy, the Large Magellanic Cloud. At a distance of about 160,000 light-years, it was the closest supernova since the telescope's invention.

Its biggest gift to astronomers arrived about 24 hours earlier. In less than a minute, one thousand trillion trillion neutrinos tore through Earth, and detectors captured about two dozen of them. The neutrinos confirmed one expectation: A supernova forms when a massive star's core collapses, and neutrinos carry away 100 times more energy than the light generated by the exploding star.

Not everything went according to plan. First, the exploding star happened to be a blue supergiant, not a red one. Second, the supernova didn't reach peak brightness for nearly 3 months — far longer than most supernovae of its type — and crested some 2 magnitudes fainter than expected. Supernova

Twenty years later, Supernova 1987A's vicinity looks like a pearl necklace as the explosion's shock wave rams gas ejected long ago by the progenitor star. The budding supernova remnant glows with a purple hue inside the ring. NASA/ESA/P. Challis and R. Kirshner (Harvard-Smithsonian CfA)

7 Galaxies hungry for a snack

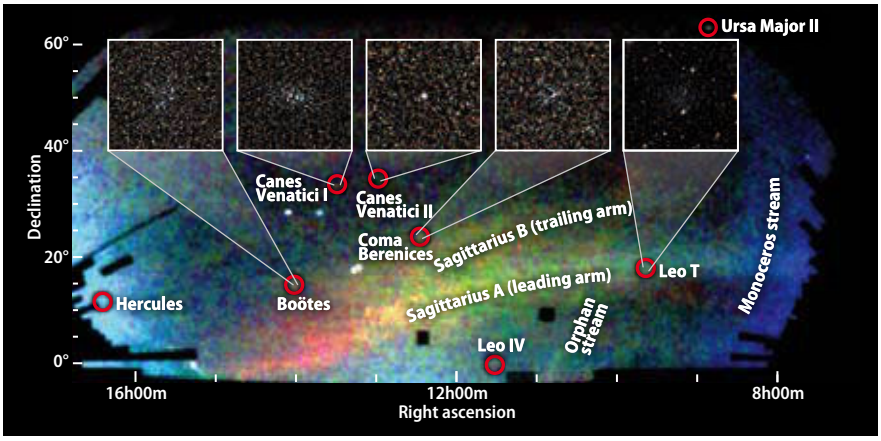
When *Astronomy* magazine began, astronomers recognized about two dozen members as the Local Group of galaxies. In the 35 years since, that number has doubled. Most of the "new" galaxies are tiny entities containing millions of stars instead of the billions seen in larger galaxies.

As the number of known dwarf galaxies skyrockets, astronomers can better understand how they interact with their bigger siblings. It appears the Milky Way and Andromeda galaxies — the Local Group's behemoths — regularly feast on these small galaxies, and have been doing so for billions of years.

It now looks as though a few of our galaxy's globular clusters may be the nuclei of dwarf galaxies swallowed by the Milky Way eons ago. The preeminent example is Omega Centauri, the galaxy's most massive globular.

In the 1990s, scientists started discovering whole galaxies being ripped apart and consumed by the Milky Way. The appetizer: the Sagittarius dwarf galaxy, discovered by Cambridge University graduate student Rodrigo Ibata in 1994. This galaxy's main bulk lies about 100,000 light-years from Earth on the far side of the Milky Way's center.

The Sagittarius dwarf opened astronomers' eyes to our galaxy's hunger. In the past decade, the Sloan Digital Sky Survey has turned up several streams of stars tied to disrupted dwarfs. Cambridge University astronomers Vasily Belokurov and Daniel Zucker and their colleagues discovered so many in an area north of the Milky Way's plane that they christened this region the "field of streams."



Stellar debris cannibalized by the Milky Way from several dwarf galaxies litters the sky. During the past 15 years, astronomers have located several dwarfs being ripped apart by our galaxy, and adding to its bulk. *Astronomy*: Roen Kelly, after Vasily Belokurov and the SDSS-II Collaboration

1987A opened astronomers' eyes to the variety of possible explosions.

Theorists still don't know exactly how core-collapse supernovae work. Researchers know a shock wave created by the core's collapse triggers the explosion. They haven't figured out, though, whether neutrinos, acoustic waves, or magnetohydrodynamics reenergize the shock so it can overcome the collapsing outer layers. The advent of 3-D computer simulations may hold the key.

Supernova 1987A also gives astronomers a ringside seat to the birth of a supernova remnant. To everyone's delight, the region around the explosion has started glowing as the expanding shock wave runs into a gaseous ring expelled by its progenitor star. The fireworks should continue for a long time.

Supernova 1987A (center right, with the massive Tarantula Nebula to its upper left) lit up the Large Magellanic Cloud in February 1987. The brightest supernova seen on Earth in nearly 400 years answered several questions about how stars blow up — and raised many more. ESO

6 Nature's biggest explosions

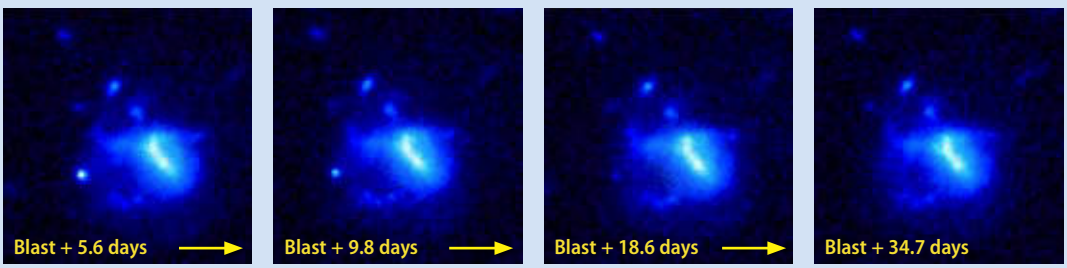
July 2, 1967, marked the birth of a new science. On that day, an intense burst of gamma rays washed over a suite of Vela satellites, launched by the U.S. military to monitor compliance with the Nuclear Test Ban Treaty. But later analysis proved this and more than a dozen subsequent bursts came not from Earth — or anywhere else in the solar system — but from somewhere beyond.

Exactly how far beyond remained unknown for decades. The bursts would appear and fade so quickly — lasting from milliseconds to a few minutes — that astronomers couldn't pin down their locations. NASA's Compton Gamma-Ray Observatory helped solve the mystery. In the early 1990s, after recording an average of nearly one burst per day, Compton data suggested the bursts came from the distant universe. If the bursts arose from objects in our galaxy, they should have lined up with the narrow band of the Milky Way. Compton's observations showed a random distribution.

The proof came from a massive burst recorded February 28, 1997. When the new Italian-Dutch satellite BeppoSAX turned its instruments on GRB 970228, it detected a fading X-ray afterglow. From this, astronomers managed to get a precise position. When observers on the ground aimed their optical telescopes at the spot, they saw a faint point of light. Further observations confirmed an extended glow in the vicinity — the burst's host galaxy.

The mystery was solved — gamma-ray bursts occur in distant galaxies (in GRB 970228's case, several billion light-years from Earth). This makes them the brightest objects in the universe, radiating more energy in a few seconds than the Sun will in its 10-billion-year lifetime.

In the past 5 years, astronomers have figured out what likely causes the bursts. (During the 1980s, inventive theorists devised more than 100 different scenarios.) Those lasting longer than about 2 seconds apparently form when massive stars explode as particularly intense supernovae. Many of the shortest bursts seem to arise from the stellar cinders known as neutron stars, either when they gather mass to form a black hole or merge with another neutron star or black hole.



The fading afterglow of a July 9, 2005, gamma-ray burst appears just to the left of center in these Hubble images of its distant host galaxy. Astronomers now know such bursts typically occur in deep space and rank as the largest cosmic explosions. NASA/Derek Fox (Penn State University)

5 Black holes exist — really

Imagine an object with so much gravity that not even light can escape from it. Science-fiction writers certainly let their minds run with this idea, but astronomers and physicists were more reluctant. This despite the fact that such objects — dubbed "black holes" by American physicist John Wheeler in 1967 — arise naturally from Albert Einstein's general theory of relativity.

A supermassive black hole at the center of the active Virgo cluster galaxy M87 powers the bluish jet seen in this Hubble image of the galaxy's core. NASA/ESA/The Hubble Heritage Team (STScI/AURA)

The first indication that black holes might exist in reality came in the early 1970s. That's when NASA's Uhuru satellite conducted the first X-ray survey of the sky. The probe discovered several X-ray-emitting binary star systems in which a visible star orbited an invisible one.

Calculations showed that in several cases, the invisible companion had more mass than could be packed into a star-sized object without becoming a black hole. The best example went by the catalog name Cygnus X-1, which appeared to contain a 10-solar-mass black hole.

Yet despite the circumstantial evidence, not all astronomers were convinced. Adroit theorists could build scenarios that didn't require a black hole. We had to wait for the 1990s, and the penetrating eye of the Hubble Space Telescope, to prove the reality of these exotic objects.

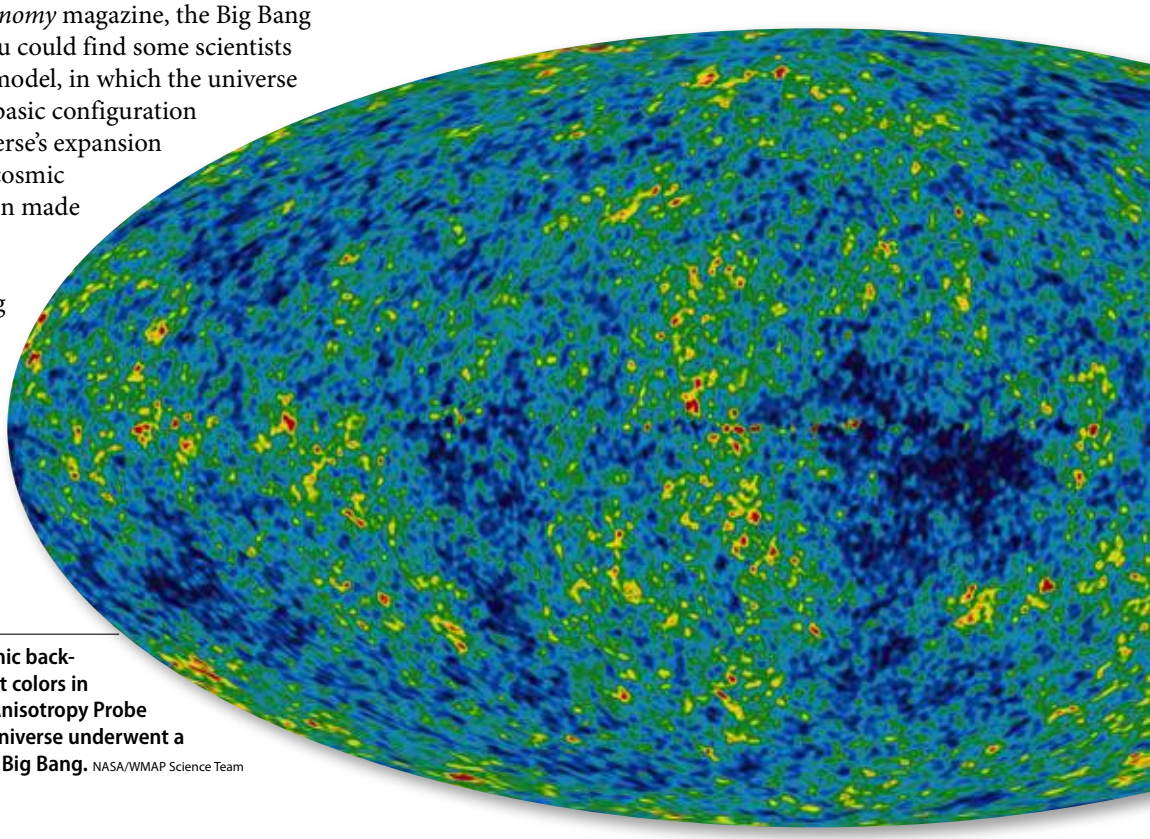
Hubble examined the cores of several galaxies millions of light-years from Earth and measured the speeds at which the innermost stars and gas clouds revolved. In nearly every galaxy they examined, Hubble scientists found the motions far too rapid — and coming from so confined a space — that the cores had to harbor a black hole containing millions or billions of times the Sun's mass.

4 Faster than a speeding bullet

At the dawn of *Astronomy* magazine, the Big Bang theory was all the rage. Sure, you could find some scientists who espoused the steady-state model, in which the universe had always existed in the same basic configuration and always would. But the universe's expansion and the 1960s discovery of the cosmic microwave background radiation made believers of most.

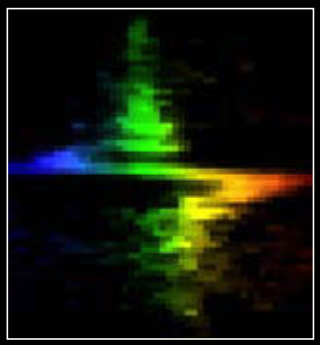
Yet, all was not perfect. Nagging concerns with the Big Bang included a cosmos tuned so finely as to seem more than a coincidence. First, the microwave background showed virtually no temperature variations, even though regions of the early cosmos never could have interacted with one another to achieve equilibrium.

Second, the universe's geometry appeared to be nearly flat. The only way that could arise was if the cosmos started out in this special state. If anything, in the early 1970s, the Big Bang model seemed a little too perfect.



Temperature fluctuations in the cosmic background radiation show up as different colors in data from the Wilkinson Microwave Anisotropy Probe (WMAP). WMAP also confirmed the universe underwent a brief period of inflation just after the Big Bang. NASA/WMAP Science Team

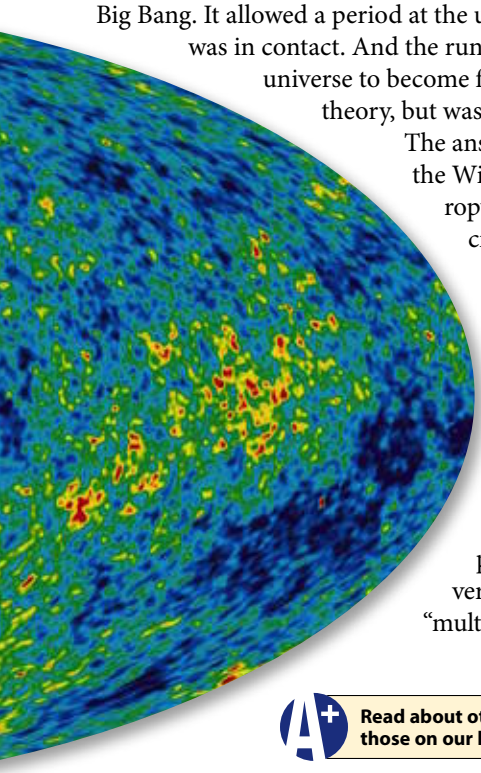
The Hubble Space Telescope, orbiting above our planet's distorting atmosphere, found the first black holes and contributed to several Top 10 discoveries. This is how it looked in 1997, at the end of the second servicing mission. NASA



Swirling gas at the center of the galaxy M84 betrays a black hole's presence. Using an imaging spectrograph, Hubble found the gas moving rapidly toward Earth (the blueshift at left) on one side and rapidly away (the redshift at right) on the other. The motion of nearly 1 million mph (1.6 million km/h) confirms a black hole weighing at least 300 million solar-masses. Gary Bower/Richard Green (NOAO)/The STIS Instrument Definition Team/NASA

In 1981, MIT particle physicist Alan Guth developed a model that took care of these problems. Building on earlier ideas, he posited that a tiny fraction of a second after the Big Bang, the cosmos experienced a brief period of hyper-expansion.

In one fell swoop, inflation solved the main problems with the Big Bang. It allowed a period at the universe's start when all matter was in contact. And the runaway expansion forced the universe to become flat. The model worked in theory, but was it true?



The answer came 25 years later with the Wilkinson Microwave Anisotropy Probe. In 2006, this spacecraft — the same one that previously had shown the Big Bang occurred 13.7 billion years ago — confirmed inflation's role in the early universe.

Inflation itself has evolved. Some theorists now talk about "eternal inflation," which raises the possibility of multiple universes. Whether we exist in such a "multiverse" may never be resolved.

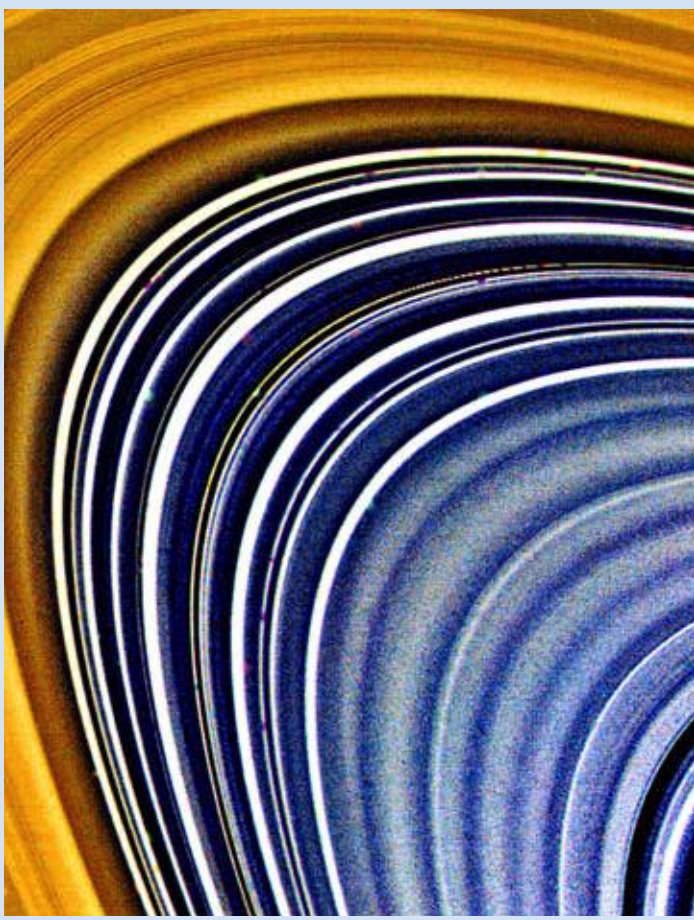
Read about other great discoveries that rivaled those on our list at www.Astronomy.com/toc.

3 Voyage of discovery

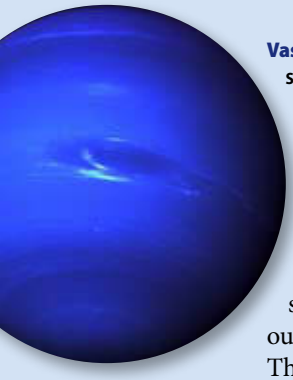
When they took off in 1977, the Voyager spacecraft were heading into nearly uncharted territory. The twin Pioneer spacecraft performed a preliminary reconnaissance of Jupiter earlier in the 1970s, and Pioneer 11 would fly past Saturn in 1979. Those spacecraft, for the most part, refined scientists' knowledge of the solar system's two largest planets.

With the Voyager probes, discoveries came fast and furious. When Voyager 1 zipped past Jupiter in March 1979, and Voyager 2 followed 4 months later, they revealed the planet's roiling atmosphere in unprecedented detail. Intricate cloud patterns driven by high-speed jet streams mesmerized scientists and the public alike. The Voyagers showed the Great Red Spot to be a giant high-pressure system, discovered auroral glows near the poles, and found a thin, dusty ring encircling the planet.

But perhaps the greatest surprises came from Jupiter's four Galilean moons. The Voyagers turned what had been points of light into vibrant worlds. Most stunning is innermost Io, where massive volcanic eruptions continually resurface the moon. At Europa, the Voyagers



Saturn's rings resolved into thousands of ringlets under the penetrating eyes of the Voyager spacecraft. This Voyager 2 view shows fine structure in the C ring (blue) and B ring (yellow). NASA/JPL



Vast storms dotted Neptune's disk when the Voyager 2 spacecraft flew past in 1989. Planetary scientists didn't expect this frigid world to show much, if any, atmospheric activity. NASA/JPL

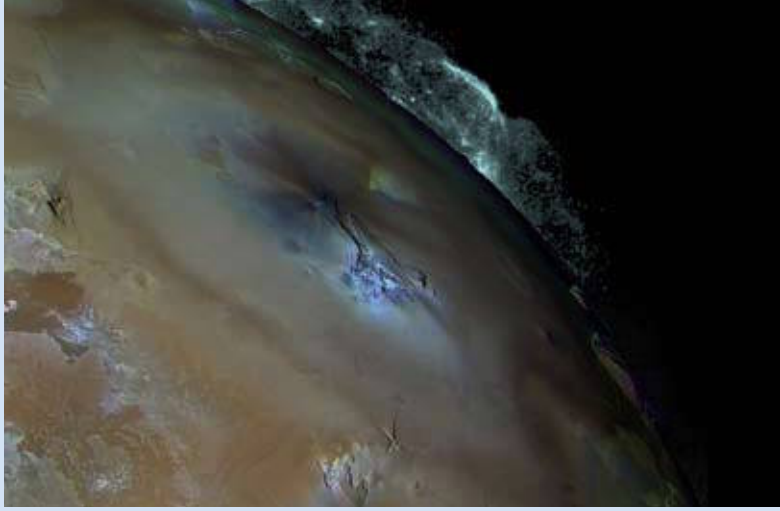
revealed a smooth surface cracked by tectonic forces — and so few impact craters that it has to be young. Ganymede has strange grooved terrain, while Callisto turns out to be the solar system's most cratered body.

The discoveries kept coming from Saturn. The Voyagers showed the ring system — thought to comprise a few broad rings — contains thousands of thin ringlets. Broad spokes inhabit the bright B ring, while the outer F ring (discovered by Pioneer 11) appears braided.

As at Jupiter, the twin spacecraft revealed Saturn's moons as worlds. Most significantly, it showed Titan's atmosphere to be nitrogen-rich (like Earth's) and with a surface pressure 50-percent greater than ours.

Only Voyager 2 made the trek to Uranus (in 1986) and Neptune (in 1989). It discovered both planets have large magnetic fields, and revealed details in their ring systems.

Surprisingly, Voyager found large storms on Neptune, a world scientists thought would to be too cold for such activity.



A massive eruption from Io's Pele volcano lofts an umbrella-shaped plume some 180 miles (300 km) above the moon's surface. The Voyager 1 spacecraft found Io to be the solar system's most active volcanic body. NASA/JPL/USGS

Most intriguing of the outer world moons is Neptune's Triton, which has a thin atmosphere and geyser-like eruptions.

After more than 30 years on the job, the Voyagers continue to operate. Both have crossed the boundary where the solar wind interacts with interstellar space and lie at least 8 billion miles (13 billion kilometers) from the Sun. No one knows how much longer they will survive in the frigid outer solar system.

2 Planets by the hundreds

Mother Nature must have a good sense of humor. She has a way of turning astronomers' expectations upside down. How else do you explain the astonishing range of planets discovered in the past 17 years?

In 1990, most scientists thought they knew what other planetary systems would look like: Small, rocky planets orbiting close to their parent stars with giant, gaseous worlds much farther out. Those stars likely would be of the normal, main-sequence variety, similar to the Sun. After all, that's how nature put our solar system together.

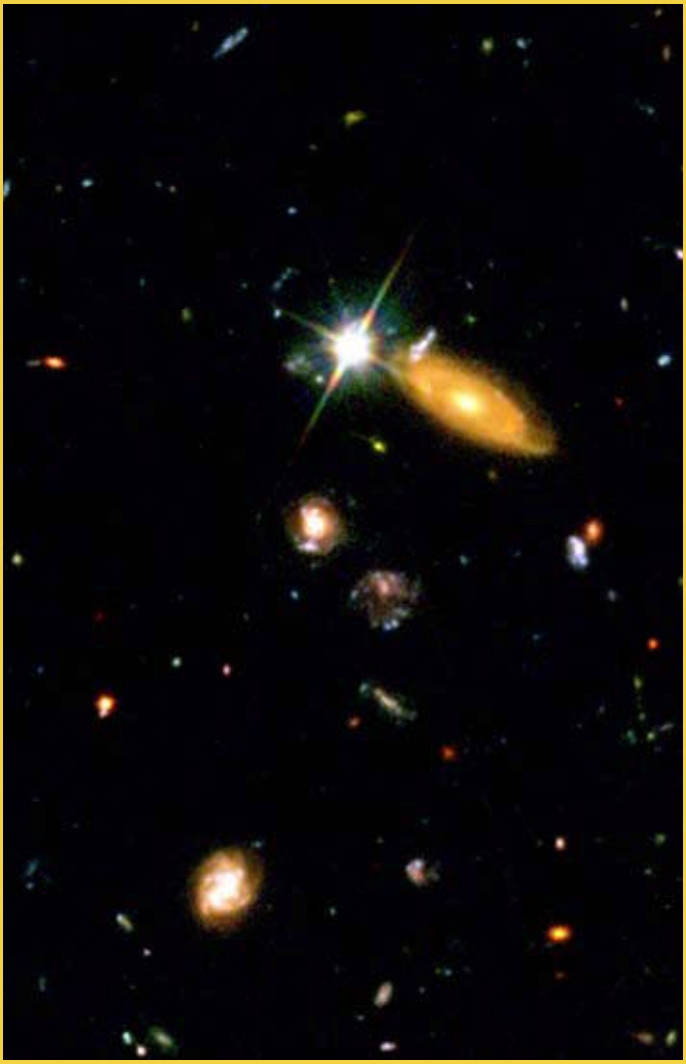
The first planets were nothing like this. In 1991, American radio astronomers Aleksander Wolszczan and Dale Frail discovered a trio of planets orbiting a rapidly spinning neutron star, or pulsar. This star long ago exploded as a supernova, which would have destroyed or banished any existing planets. The first known exoplanets formed in a totally unexpected and alien way.

Four years later, Swiss astronomers Michel Mayor and Didier Queloz found the first planet around a Sun-like star, 51 Pegasi. This planet has the audacity to be Jupiter's size yet orbit its star in just 4.2 days at only 1 percent the distance of Jupiter from the Sun.

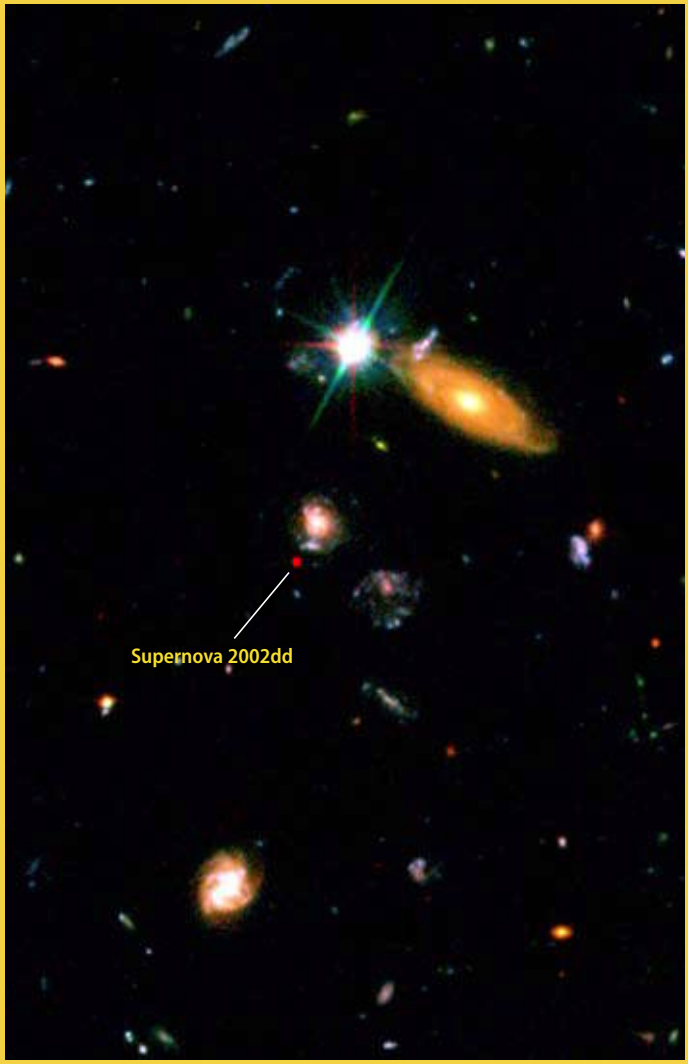
Astronomers have discovered plenty more "hot Jupiters" in the years since. Based on the nearly 300 exoplanets now known, such planets seem less freaks of nature than our own solar system.

But most planet-hunting techniques still favor finding massive planets in orbits close to their stars. In the years since 1995, planets both smaller and more distant from their suns have turned up. Astronomers have found several planets smaller than Neptune, and the trend toward smaller and more earthlike planets continues.

At least three planets, the smallest (foreground in this artist's impression) just five times Earth's mass, orbit the red-dwarf star Gliese 581. In the past 13 years, astronomers have detected nearly 300 planets around normal stars. ESO



The Hubble Deep Field (only a small part of this historic 1995 image is shown here) revealed some 1,500 galaxies stretching billions of light-years from Earth. As the deepest view of the cosmos up to that time, the image provided astronomers with a treasure trove of discoveries. NASA/J. Blakeslee (JHU)



Supernova 2002dd, a type Ia supernova, exploded in the same field nearly 7 years after Hubble took the original image. At a distance of 8 billion light-years, this supernova helped shed light on the dark energy that pervades the universe. NASA/J. Blakeslee (JHU)

1 Dark energy's dark future

In the *Star Wars* saga, Darth Vader attempted to rule a galaxy through his mastery of the dark side of The Force. The evil Sith Lord apparently set his sights too low. In just the past decade, astronomers have learned that a mysterious force known as dark energy controls the entire universe's fate.

The detection of dark energy not only ranks as the top discovery of the past 35 years, it is also the most surprising. In 1998, two teams of astronomers — one led by Saul Perlmutter of the University of California, Berkeley, and the other by Brian Schmidt of Mount Stromlo Observatory in Australia — announced their findings.

Using the Hubble Space Telescope and several large ground-based scopes, both groups had been observing distant type Ia supernovae. These explosions occur in binary star systems in which one member is a white dwarf and the other a red giant. The white dwarf's strong gravity pulls in material from the red giant's distended atmosphere. Once the white dwarf exceeds 1.4 times the Sun's mass, it immediately detonates.

Because all type Ia explosions arise from nearly identical progenitor stars, their peak luminosities also match. So, if you measure how bright one of these supernovae appears, you can calculate its distance. Perlmutter's and Schmidt's teams found the farthest type Ia supernovae were fainter than their distances implied. The only way this makes sense is if some force is accelerating the universe's expansion — a force most cosmologists attribute to dark energy.

According to the Wilkinson Microwave Anisotropy Probe, dark energy currently accounts for 72 percent of the universe's contents. Mysterious dark matter contributes another 23 percent. This leaves just 5 percent for the ordinary matter that makes stars, planets, and people.

If dark energy dominates the universe in the future as much as it does now, every galaxy beyond our own eventually will recede beyond our ability to see it. The observable universe will be reduced to a single galaxy, which would make Darth Vader, at least, very happy.

The sky this month

Martin Ratcliffe and Alister Ling describe the solar system's changing landscape as it appears in Earth's sky.

August 08

A pair of summer eclipses

A diamond ring and pinkish prominences crest above the Moon's limb in this view of the March 29, 2006, total solar eclipse. Judy Bowen

Darkness comes at midday for those on a narrow path that stretches from northern Canada across the Arctic Ocean into northern Asia. *Astronomy*: Roen Kelly

Four planets gather in the twilit summer evening sky: Mercury, Venus, Mars, and Saturn. Because every planet moves at a different speed and rhythm, this assembly creates a number of fascinating conjunctions. The scene will be ripe for wide-angle photography. Unfortunately, none of these planets lies high enough to yield good views through a telescope.

Jupiter appears high in the south at dusk and remains visible for most of the night. The dynamic planet appears higher than the horizon dwellers, and should present some nice telescopic views. Meanwhile, distant Uranus and Neptune both lie within reach of binoculars.

Let's begin our tour in the western sky shortly after sunset. As August begins, the crescent Moon glides beneath three planets over a 3-day period. On August 2, Venus becomes visible low in the west within 30 minutes of sunset. Look for a slender Moon 7° to its left — binoculars will help you spy the faint crescent. Also see if you can spot Regulus, Leo's preeminent star, which lies between the Moon and Venus.

Next, scan a bit less than two binocular fields to the upper left of Venus. There, lurking in bright twilight, you should see Saturn. Mars stands a similar distance to the ringed planet's upper left.

44 Total eclipse of the Sun
57 Meteor watch
57 Rising Moon
58 When to view the planets
58 Evening planets on parade
58 Comet search
59 Spying asteroids
59 Partial lunar eclipse

Visible to the naked eye
Visible with binoculars
Visible with a telescope

By August 3, the fattening crescent Moon has shifted to the left. It then lies 6° below and a little to the right of Mars. Spotting 2nd-magnitude Mars — more than 100 times dimmer than Venus — is tricky in bright twilight. You'll need binoculars to track down the Red Planet.

Venus stands out as the brightest object in the western sky after sunset. Gleaming at magnitude –3.8, it serves as a useful guide to the rest of the planetary movements this month. Watch during August's first 2 weeks as Venus and **Saturn** close in on each other. Along the way, Venus passes 1° north of Regulus August 5.

By August 8, you might spot **Mercury** a mere 2° above

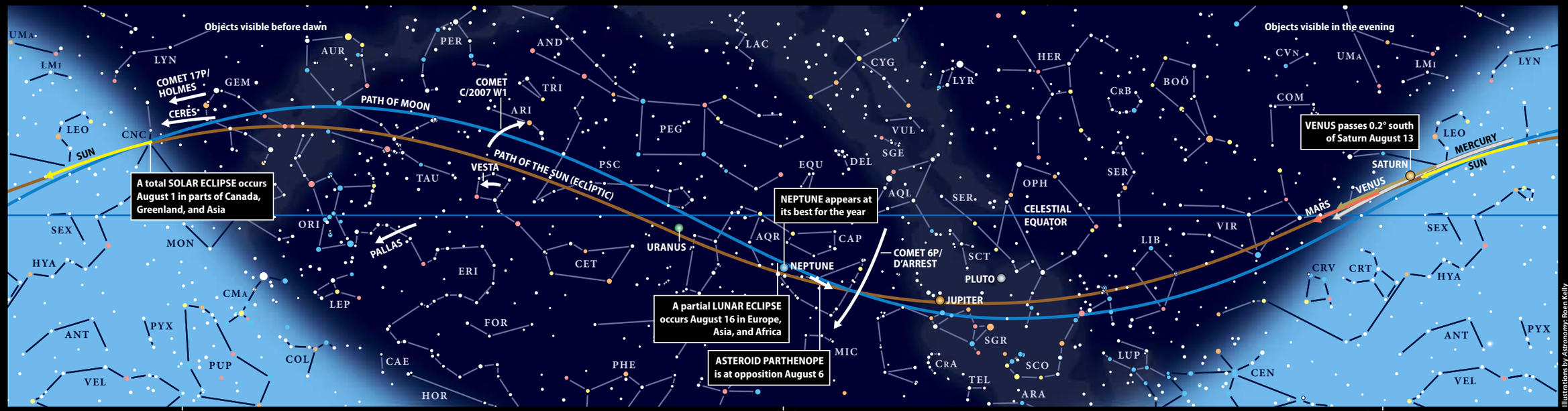
— *Continued on page 57*

Planets in August 08

This map unfolds the entire night sky from sunset (at right) until sunrise (at left).
Arrows and colored dots show motions and locations of solar system objects during the month.

Astronomy magazine

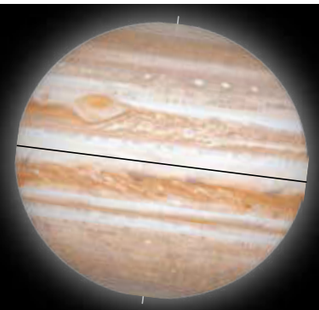
Path of the planets

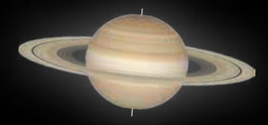


MOON PHASES

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

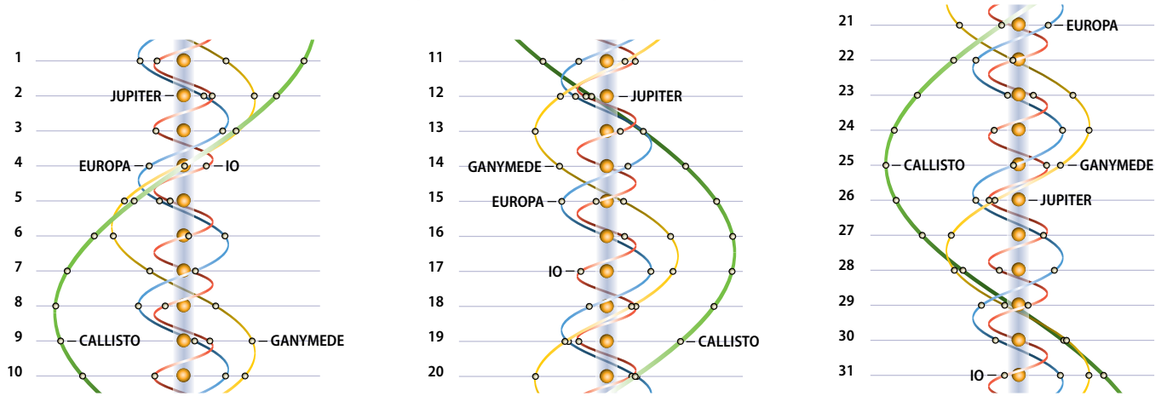
PLANETS	MERCURY	MERCURY	VENUS	MARS	CERES	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	August 15	August 31	August 15	August 15	August 15	August 15	August 1	August 15	August 15	August 15
Magnitude	–0.5	0.0	–3.8	1.7	8.8	–2.6	0.8	5.7	7.8	13.9
Angular size	5.2"	6.0"	10.4"	4.0"	0.4"	45.4"	16.3"	3.7"	2.4"	0.1"
Illumination	88%	71%	95%	97%	99%	100%	100%	100%	100%	100%
Distance (AU) from Earth	1.289	1.116	1.607	2.351	3.485	4.339	10.202	19.208	29.025	30.903
Distance (AU) from Sun	0.415	0.465	0.721	1.624	2.602	5.164	9.324	20.098	30.037	31.507
Right ascension (2000.0)	10h40.2m	12h07.4m	10h51.0m	11h50.3m	8h02.7m	18h58.0m	10h39.7m	23h30.6m	21h40.8m	17h53.9m
Declination (2000.0)	9°37'	–1°50'	8°52'	1°47'	24°16'	–23°02'	10°15'	–4°03'	–14°16'	–17°13'





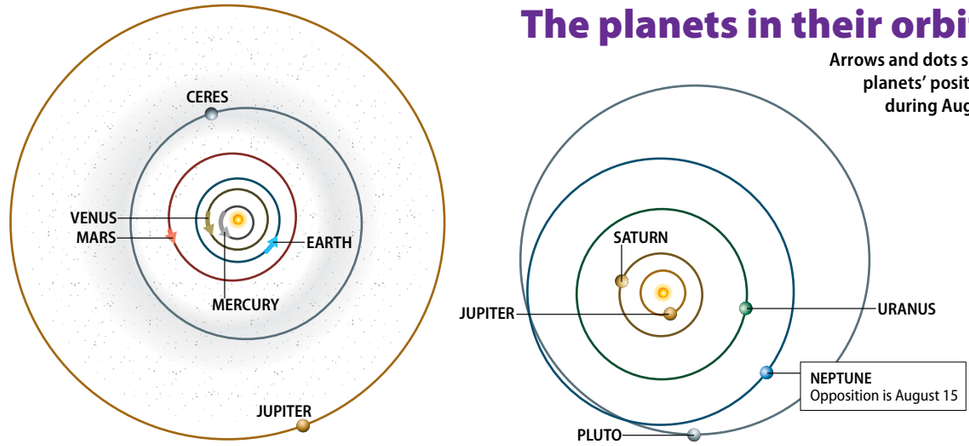
Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown.
South is at top to match the view through a telescope.



The planets in their orbits

Arrows and dots show planets' positions during August.



StarDome

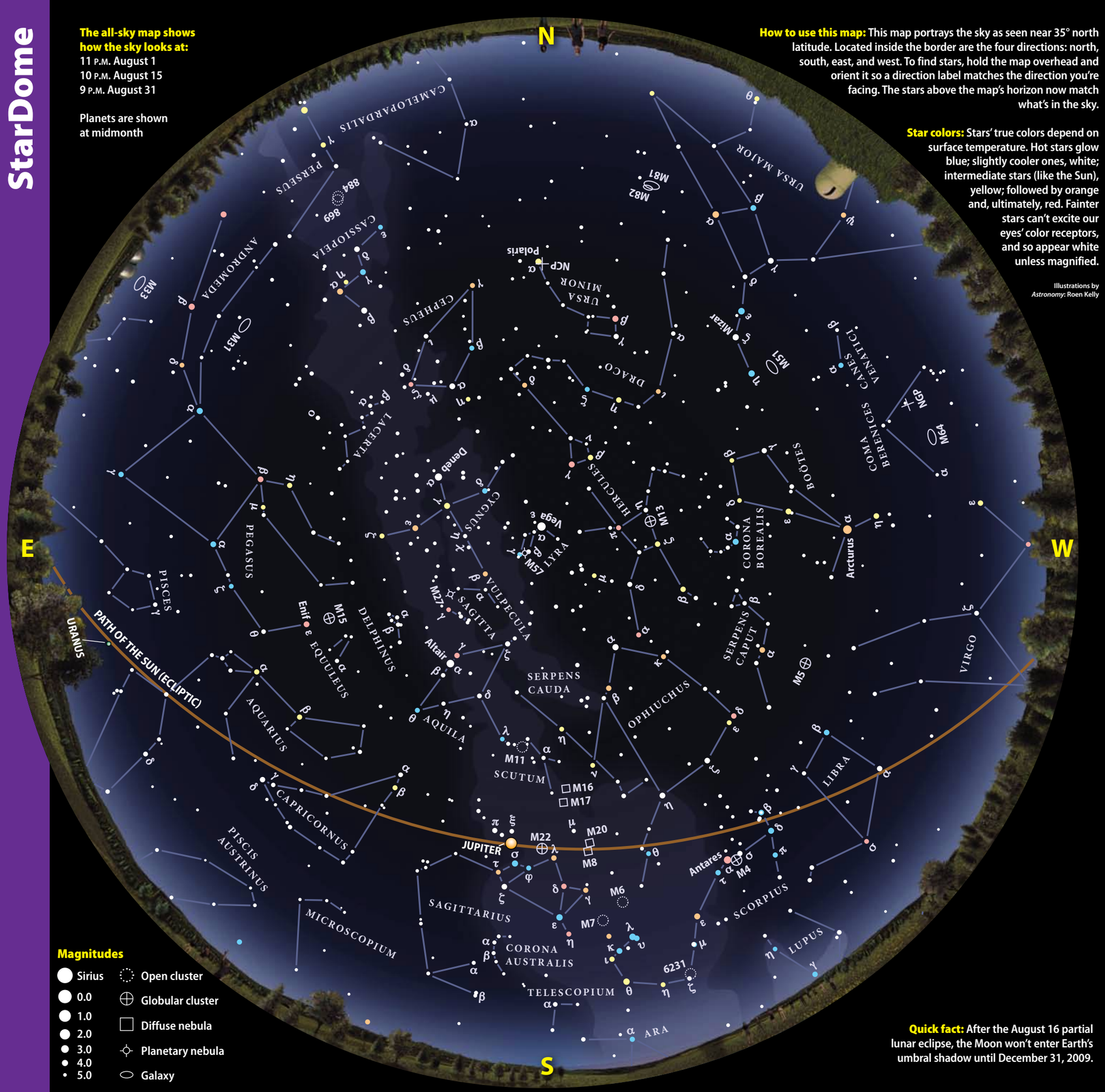
The all-sky map shows how the sky looks at:
11 P.M. August 1
10 P.M. August 15
9 P.M. August 31

Planets are shown at midmonth

How to use this map: This map portrays the sky as seen near 35° north latitude. Located inside the border are the four directions: north, south, east, and west. To find stars, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Star colors: Stars' true colors depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

Illustrations by *Astronomy*: Roen Kelly



Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0
- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

Quick fact: After the August 16 partial lunar eclipse, the Moon won't enter Earth's umbral shadow until December 31, 2009.

August 08

Note: Moon phases in calendar vary in size due to distance from Earth and are shown at 0h Universal Time.

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Calendar of events

1 New Moon occurs at 6:13 A.M. EDT; total solar eclipse

Special observing date

Aug. 1: A solar eclipse brings up to 2.5 minutes of totality to Asia.

2 The Moon passes 2° south of Venus, 11 A.M. EDT

3 The Moon passes 4° south of Saturn, 10 A.M. EDT

4 The Moon passes 4° south of Mars, 8 A.M. EDT

5 Venus passes 1.1° north of Regulus, 4 P.M. EDT

6 Asteroid Parthenope is at opposition, 11 A.M. EDT

8 First Quarter Moon occurs at 4:20 P.M. EDT

10 Mercury passes 1.1° north of Regulus, 1 A.M. EDT

The Moon passes 0.4° south of Antares, 3 P.M. EDT

The Moon is at apogee (251,380 miles from Earth), 4:18 P.M. EDT

12 Perseid meteor shower peaks

13 The Moon passes 3° south of Jupiter, 10 A.M. EDT

Venus passes 0.2° south of Saturn, 3 P.M. EDT

15 Neptune is at opposition, 4 A.M. EDT

Mercury passes 0.7° south of Saturn, 8 P.M. EDT

16 The Moon passes 0.8° north of Neptune, 3 P.M. EDT

Full Moon occurs at 5:16 P.M. EDT; partial lunar eclipse

18 The Moon passes 4° north of Uranus, 10 P.M. EDT

23 Mercury passes 1.2° south of Venus, 1 A.M. EDT

Last Quarter Moon occurs at 7:50 P.M. EDT

25 The Moon is at perigee (229,097 miles from Earth), 11:59 P.M. EDT

30 New Moon occurs at 3:58 P.M. EDT

For definitions of terms, log onto www.Astronomy.com/glossary.

Astronomy magazine

Astronomy magazine's first 35 years

Some of the most important astronomical events have occurred since our magazine's birth. **by David J. Eicher**

Growing up with amateur astronomy

Here's how a chance encounter with Saturn led to Editor David J. Eicher's lifelong love of astronomy.

When I was a teenager, my interest leaned toward medicine, a physician's career, I thought. Then, at age 14, I went to a star party and saw Saturn through a telescope. All other interests ceased — the sky became my obsession.

I grew up in Oxford, a small town in Ohio. Miami University was the main event. My father John, now Professor Emeritus of Chemistry at the university, was then a professor. The town had Miami, farmland, and not much else.

My immersion in amateur astronomy led to an adventure I could not have foreseen. The astronomy club that held the star party enlisted me to write for its monthly newsletter. Armed first only with binoculars, and later an 8-inch telescope, I observed and sketched so many objects that I regularly stayed up all night and went directly to high school the next morning.

Soon, my love for the heavens led me to create a magazine about deep-sky observing. In June 1977, the first issue of *Deep Sky Monthly* rolled off the mimeograph machine in my father's chemistry office. Members of the Astronomical Association of Oxford and amateurs from Cincinnati and Dayton took pity on me and subscribed. After a few issues, *Deep Sky Monthly* had more than 100 paid subscriptions.

Publishing this magazine became a family affair. My father and I traveled to use a press loaned to us at the Dayton Museum of Natural History. Later, we had the magazine printed commercially in nearby Hamilton.

I had become acquainted with the editors at the two big astronomy magazines, and made it no secret that I would love to work for them one day.

The finished product. Fifteen-year-old Eicher displays new copies of *Deep Sky Monthly* with his father John at the 1977 Apollo Rendezvous in Dayton, Ohio. David J. Eicher

In 1982, Richard Berry, then editor of *Astronomy*, offered me a job. Astromedia Corp. also agreed to buy *Deep Sky Monthly*. In September 1982, I started as assistant editor of *Astronomy* and editor-in-chief of *Deep Sky* magazine, the latter's circulation more than 1,000 subscribers. I have been with *Astronomy* ever since.

Times have changed. Observers today view and image Sharpless nebulae, elliptical galaxy Maffei 1, and sparse Abell galaxy clusters. After Hale-Bopp and Hyakutake in the mid-1990s, we're overdue for a really bright comet.

I don't observe as much as in the early days, because of staying busy with my family and living in a place without a dark sky. Yet, after all the experiences of the last quarter century, I can return to that Ohio farm field where I first set up my scope and, with my border collie Oscar, stayed out all night, exploring galaxy after galaxy. It was all a mystery then. I hope that *Astronomy* helps you with that magical sense of exploration that I first experienced. ◑

Dave Eicher and his 8-inch Schmidt-Cassegrain telescope in 1977. David J. Eicher

1973–1977: Astronomy *blasts off*

***Astronomy* magazine launches as a new age of solar system exploring begins.**

1973

Spring:
- **Founder, publisher, and editor Stephen A. Walther creates AstroMedia Corp. in September 1972 and produces the first issue of *Astronomy* by spring 1973.**
- Celestron offers a 14-inch Schmidt-Cassegrain telescope.

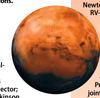
August:
- **The first issue of *Astronomy* is published with 48 pages.**
- Stellafane, the oldest meeting of amateur astronomers in the United States, celebrates its 50th anniversary in Springfield, Vermont.

October:
- The third issue features an article on Mars by Carl Sagan and a preview of the upcoming Comet Kohoutek appearance.

December 3:
- **Pioneer 10 passes Jupiter.**

1974

January:
- **Comet Kohoutek fails to live up to expectations.**



March 29:
- **Mariner 10 arrives at Venus.**

September:
- Stephen Walther named *Astronomy*'s editorial director; Terence Dickinson becomes editor.

December 4:
- Pioneer 11 makes its closest approach to Jupiter.

1975

January:
- *Astronomy* expands to 80 pages with articles by George Abell and William K. Hartmann.
- Orion Telescopes and Binoculars opens for business.
- Magazine ads were dominated by Celestron SCTs, Meade research quality telescopes and accessories, Cave Astrola Newtonians, and the Dynascope RV-6 reflector.

May:
- The European Space Agency is formed.

July:
- The Apollo-Soyuz Test Project marks the first joint space venture between the United States and the Soviet Union.

1976

January:
- Russian engineers finish the Bolshoi Azimuthal Telescope. At 236 inches, it was the world's largest telescope, but it didn't perform as expected.

March:
- **Comet West (C/1975 V1) dominates the sky.**

April 8:
- Mars occults the bright star Epsilon Geminorum.

July
- **Astronomy publishes a special issue on the history of American astronomy.**

July 20:
- Viking 1 touches down on the Red Planet.

September 3:
- **Viking 2 lands on Mars.**

1977

January:
- Edmund Scientific Co. introduces the popular Astroscan, a 4¼-inch Newtonian reflector.
- Meade Instruments Corp. offers a pair of reflectors so popular that orders are backlogged for months.
- Al Nagler creates Tele Vue Optics in Spring Valley, New York.

February:
- Bob Maas joins the *Astronomy* staff as president of AstroMedia Corp.

September 14:
- Stephen Walther dies of a brain tumor at age 33.

November:
- At Palomar Mountain Observatory, astronomer Charles Kowal finds a weird asteroid he names Chiron; 11 years later, it develops a comet-like coma, suggesting a connection between comets and asteroids.

December:
- **Richard Berry becomes editor of *Astronomy*.**

The Hurtling Moons of Barsoom

by Carl Sagan, October 1973

This article, a chapter from Sagan's book,* The Cosmic Connection: An Extraterrestrial Perspective *(Doubleday & Company, 1973), outlined our understanding of Mars and its moons, Deimos and Phobos.

In my childhood I was lucky enough to come upon a set of turgidly written novels with names like **Thuvia, Maid of Mars**, **The Chessman of Mars**, **The Princess of Mars**, **The Warlords of Mars**, and so on. They were, needless to say, about Mars. They were not about "our" Mars — the Mars revealed by Mariner 9.

At least I don't think our Mars is like the Mars of these novels by Edgar Rice Burroughs, the inventor of Tarzan. His Mars was Percival Lowell's Mars — a planet of ancient sea bottoms, working canals and pumping stations, six-legged beasts of burden, and men (some headless) of all colors, including green.

But the name invented by Burroughs that has haunted me across the years is the name he imagined the Martians gave to Mars: Barsoom.

Mars

Io

by David Morrison, February 1976

Morrison examined the composition and evolution of this mysterious Galilean moon.

If people ever set foot on Io, it will be from behind several inches of lead.

This frozen, airless world — as large as Mercury, but 500 million miles from the sun — would be inhospitable by any standards. But Io is particularly cursed.

Io

Bathed in the heat of Jupiter at its formation, Io has never broken the bond with its giant neighbor which now wraps it in a deadly shroud of high energy radiation. Vast electric currents move between Jupiter and Io, and a continuous blast of electrons and protons strikes the satellite's surface.

Io is one of the four "Galilean" satellites of Jupiter (so-called after their discoverer); the others are Europa, Ganymede, and Callisto. They are much larger that the other Jovian moons and their orbits are closer to the planet.

Miniblack Holes

by Barry Parker, February 1977

Following the Big Bang, did primordial tiny black holes populate the early universe?

The only thing needed for a collapsing star to become a black hole is sufficient mass — an amount somewhere between two and six solar masses. Until a few years ago the collapse theory appeared to be the only way black holes could be produced. In 1970, however, scientists began to consider the possibility that they were also formed in the universe's early history.

By taking a close look at the initial stages of the big bang, we find that if this event was not homogeneous (that is, if matter formed in it did not expand evenly), an interesting phenomenon might have occurred. Pockets of small regions of matter may have become compressed as expansion took place around them. Some of these pockets would likely become back holes.

To read the magazine articles previewed here in their entirety, visit www.Astronomy.com/toc.

Top to bottom, left to right: *Astronomy*; NASA/JPL; NASA/J. Bell (Cornell University) and M. Wolff (SSI); W. Edward Browne; NASA/JPL; Ronald E. Royer; *Astronomy*; NASA; *Astronomy*; David J. Eicher

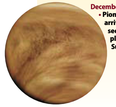
1978–1982: Growing into the leader

The first shuttle launch and Dobsonian revolution mark an electrifying period in astronomy coverage.

1978

July 22:
- Pluto's moon Charon discovered.

October:
- **AstroMedia begins publishing *Telescope Making*, a quarterly, with Richard Berry as editor.**
- Robert Burnham begins his long career at *Astronomy* as an associate editor.



December 4:
- **Pioneer Venus arrives at the second closest planet to the Sun.**

1979

January:
- **AstroMedia begins publishing *Odyssey*, a children's astronomy magazine, with Nancy Mack as editor.**
- The Multiple-Mirror Telescope, with six 72-inch mirrors, is completed on Mount Hopkins, Arizona.
- The first nebula filters are advertised, promising to eliminate sky-glow and make deep-sky objects look better.

February 26:
- A total solar eclipse graces the northwestern United States.

March:
- Voyager 1 encounters Jupiter.

April:
- Astronomers find a supernova in spiral galaxy M100.

July:
- Voyager 2 encounters Jupiter.

August:
- The first Texas Star Party is held in the Davis Mountains of West Texas.

September:
- Pioneer 11 passes Saturn.

1980

- Meade introduces the System 2000 line of improved Schmidt-Cassegrain telescopes.
- *Odyssey* 1, the first large scope on a Dobsonian mount, is introduced by Coulter Optical.
- Tele Vue Optics introduces the revolutionary Nagler eyepiece line, which will change observing and the expectations of skywatchers.
- Near Socorro, New Mexico, the Very Large Array radio telescope comes on line.
- *Astronomy* publishes an article on how to build your own Dobsonian telescope, which, along with *Telescope Making* articles, pushes forward the Dobsonian revolution.

September:
- **Cosmos, Carl Sagan's PBS series, premieres and popularizes astronomy like no other television production before.**

November:
- Voyager 1 flies by Saturn.

1981

- *Astronomy* surpasses *Sky & Telescope* as the top-selling magazine on the subject.
- Roland Christen of Astro-Physics creates the first "color-free" refractor lens.
- Image intensifier devices become fashionable, providing electric-green views of stars and nebulae.

April 12:
- **Columbia heads to space on a 3-day mission — the first-ever shuttle flight.**

August:
- **Voyager 2 encounters Saturn.**

1982

March:
- Venera 13 and 14 arrive at Venus.

September:
- Francis Reddy joins the staff as an assistant editor of *Astronomy*. He will leave in 1985 only to return as an associate editor in 2004.

- ***Astronomy* buys *Deep Sky Monthly*, retitles it *Deep Sky*, and publishes it as a quarterly, hiring David Eicher as editor.**

The Early History of Planet Earth

by William K. Hartmann, August 1978

Early in our planet's history, volcanos spewed molten rock and gases to the surface, adding water, carbon dioxide, and other gases to the primitive atmosphere.

We live and walk around on a ball of magnesium silicates and iron that formed in a cloud of dust and gas some 4-½ billion years ago. In short, Earth is the closest planet and most accessible astronomical object. The rocks beneath our feet may shed light on less easily reached places that exist elsewhere in the solar system — or on Earth sized masses near other stars.

The early history of Earth is of special interest; it marks a period of transition from a time when the main processes affecting Earth were external (or astronomical) to a time when they were internal (or geological). Earth's formation was, by definition, entirely astronomical — particles orbiting a central star aggregated into a planet. Later, external cosmic influences (such as a rain of meteorites, nearby supernovae, and strong solar winds) continued to dominate.

The First Second of Time

by Barry Parker, August 1979

What occurred during the first moments immediately following the Big Bang?

Just try to picture the following: everything that we see around us, out to the farthest limits of the largest telescopes — the whole universe — is crushed and packed into a volume smaller than that of an atom. Then suddenly an explosion of unimaginable intensity takes place and everything is thrown outwards at velocities approaching that of light. The universe is born in a single violent instant of unbelievable chaos. This explosive beginning is called, appropriately enough, the Big Bang.

What was it like? Certainly there's no way we could ever really visualize it — that's beyond our powers of imagination. But we can piece together the events that occurred to get an idea of what happened, for example, in the first second after the Big Bang.

Earth and Voyager

Voyager: Science at Saturn

by Richard Berry, February 1981

Voyager 1's cameras captured the complexity of the ringed world and its moons.

With the Voyager reconnaissance of Saturn, the first stage of planetary exploration is drawing to a close. There will be other explorations into the unknown — of comets, of asteroids, of the outer planets, of the magnetic and particle environment around the Sun — but never again will we explore so many new worlds.

Humans now know firsthand what every celestial body in the Copernican/Keplerian solar system looks like, know whether it possesses an atmosphere and a magnetic field, know to a first approximation the processes that have shaped its surface, and the nature of the stuff that fills its insides. There are 23 bodies in that roster — ranging from the tiny rock chunk moons of Mars to the hydrogen giant planet Jupiter that exceeds all the rest together with its mass.

Top to bottom, left to right: *Astronomy*; NASA/JPL; NASA-GRC; *Astronomy*; Random House; NASA/JPL; NASA; Voyager art: NASA/JPL; *Astronomy*

1983–1987: Halley's Comet returns

The most famous comet reenergizes amateur astronomy.

1983

January 25:
- The Infrared Astronomy Satellite (IRAS) is launched.

May:
- **Comet IRAS-Araki-Alcock, a puffball without a significant tail, speeds across the sky, moving as much as 40° per day.**

June:
- Pioneer 10 leaves the solar system.

June 11:
- **A total solar eclipse covers Indonesia in darkness.**

June 18:
- Sally Ride becomes the first U.S. woman in space.

1984

- Meade releases integrated electronic drive systems for its Schmidt-Cassegrains.

February:
- The first Winter Star Party is held in the Florida Keys.

February 7:
- Bruce McCandless becomes the first astronaut to make an untethered spacewalk.

May 30:
- An annular eclipse passes over North America.

August:
- **The Astronomical League holds ALCON, its annual meeting, at Carroll College in Waukesha, Wisconsin, co-hosted by *Astronomy*.**

1985

- Kalmbach Publishing Co. buys AstroMedia Corp. and begins publishing *Astronomy*, *Odyssey*, *Deep Sky*, and *Telescope Making*.

June:
- *Astronomy* publishes the first of many articles on observing Comet Halley, which brightens to telescopic visibility in August.

October:
- **A special issue devoted to Halley's Comet welcomes back the celestial visitor. Two other relatively bright comets, Giacobini-Zinner and Hartley-Good, share the sky with Halley.**

1986

January 24:
- **Voyager 2 reaches Uranus.**

January 28:
- **The Space Shuttle Challenger is destroyed after launch, killing its crew of seven.**

March:
- Comet Halley puts on its best show since 1910; several spacecraft including the European Giotto fly past Halley's nucleus.

May:
- Richard Talcott joins the staff as an assistant editor.

1987

- **The ATI *CAT*, an early computer-based finding device for SCTs, previews go-to technology to come.**

February 23:
- **Supernova 1987A erupts in the Large Magellanic Cloud.**

Summer:
- Pluto and Charon undergo the first of a series of rare 1980s transits.

November:
- Comet Bradfield (1987s) makes a naked-eye appearance in the Milky Way.

A Bigger & Better Milky Way Galaxy

by Bart Bok, January 1984

Astronomer Bart Bok described the research that proved that the Milky Way was a much richer place than previously thought.

Due to new research techniques, our picture of the Milky Way Galaxy has changed dramatically during the past few years. In 1973, the maximum radius of the Galaxy was about 20 kiloparsecs. The new radius is at least three times — and possibly five times — the earlier value. Whereas the mass of our 1973 Galaxy was 100 to 200 billion solar masses, newer evidence from the large rotational motions of galactic gas clouds and the motions of a dozen or so outlying globular clusters indicate a total mass of at least 600 billion solar masses, possibly even 1 to 2 *trillion* solar masses.

The Milky Way's glow

What Have We Learned from Comet Halley?

by Richard Berry and Richard Talcott, September 1986

Observations in 1986 gave us our closest and most revealing views of Comet Halley.

As the huckster's call — "Step right up, folks, it's a once-in-a-lifetime experience" — fades into astronomical memory, you may wonder: What was it all about? Why the hoopla and why the hype, why the excitement and why the pronouncements? Was it all worth it? If we take at face value that we set out to learn something about comets from Comet Halley, then what *did* we learn from Comet Halley?

Well, it turns out that we've learned a lot. Although it will be years before all the data collected have been thoroughly analyzed, astronomers have already begun announcing their findings.

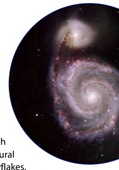
How Do Spiral Galaxies Spiral?

by Neil Comins and Laurence Marschall, December 1987

Two leading professors of astronomy described how computer simulations detail the formation of spiral galaxies.

From the very small to the incredibly large, there are countless examples of objects in our universe with shapes determined by natural forces. The shapes of snowflakes, for example, reflect the geometric structure of electric forces exerted between atoms in water molecules. The delicate filigree we see at the edges of sunspots and the arcs of gigantic loop prominences on the Sun trace the patterns of solar magnetic field lines.

Yet force cannot always be readily deduced from form. The shapes of spiral galaxies, which rank among nature's most striking forms, resist straightforward interpretation, despite over four decades of research.



The Whirlpool Galaxy

Top to bottom, left to right: Marco Milani; Daniel Fischer; *Astronomy*: Robert Burnham; John Chumack; ROE/AAT; NASA/JPL; NASA; Chandra/Harvard; NASA/ESA/S. Beckwith (STScI)/Hubble Heritage Team (STScI/AURA)

1988-1992: The greatest telescope launches

The Hubble Space Telescope and other observatories change how we see our universe.

1988

March 18:
- A total solar eclipse occurs over the South Pacific.

July:
- Phobos 1 and 2 are launched toward Mars

September 22:
- Mars is at opposition, only 36 million miles from Earth.

September 29:
- NASA launches its first shuttle mission after the Challenger disaster.

1989

- A new generation of Dobsonians, featuring aluminum struts covered by canvas rather than a solid tube, makes large scopes more portable.

August:
- **Voyager 2 encounters Neptune.**

November 18:
- **The Cosmic Background Explorer satellite is launched.**

1990

- Astro-Physics Inc. releases synthetic fluorite ED glass, which eliminates color fringes.
- Meade offers the Smart Drive, the first permanently programmed correction software.

April:
- Comet Austin (1989 C1) makes a respectable showing.

April 24:
- **The Hubble Space Telescope is launched into orbit.**

September:
- **The Magellan spacecraft begins mapping Venus.**

1991

January:
- Cosmic Background Explorer satellite data help confirm Big Bang theory.
- Kalmbach sells *Odyssey* to Cobblestone Publishing Co.

April 5:
- Compton Gamma Ray Observatory is launched.

July 11:
- A total solar eclipse passes over Central America and the Baja in Mexico.

1992

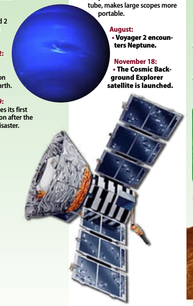
January 9:
- **Astronomer Alexander Wolszczan announces the discovery of a planet orbiting the pulsar PSR B1257+12, the first extrasolar planet discovered.**

February:
- Kalmbach discontinues *Deep Sky* and *Telescope Making* magazines.

May:
- **Robert Burnham becomes editor of *Astronomy*.**

August:
- The first Northeast Astronomy Forum is held in Suffern, New York.

September 25:
- Mars Observer launches; communication is lost 11 months later.



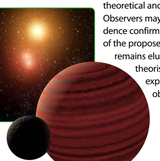
Do Brown Dwarfs Really Exist?

by Deborah Byrd, April 1989

Before astronomers verified the first brown dwarf in 1995, Byrd detailed the search for these bodies.

Some astronomical objects exist in the minds of astronomers before they are discovered in the real universe. Neutron stars, for instance, were postulated in the 1930s, long before pulsars were discovered and found to be neutron stars in the late 1960s. Similarly the existence of the cosmic microwave background radiation that permeates space was predicted some fifteen years before Bell Laboratories researchers Arno Penzias and Robert Wilson discovered this relic of the Big Bang explosion.

On the other hand, some objects start out theoretical and stay that way. Observers may search, but evidence confirming the existence of the proposed objects remains elusive. Eventually theorists have to explain why the objects *don't* exist.



Brown dwarf and its companion

Top to bottom, left to right: NASA/JPL; NASA; Brown dwarf art: Robert Hurt, IPAC; NASA; NASA/JPL; *Astronomy*: David J. Eicher; NASA/JPL-Caltech

The First Planet Beyond the Solar System

by Robert Burnham, with contributions from Barkat Sorathia, December 1991

Astronomers mistakenly identified the first-known exoplanet based on the activity of pulsar 1829–10.

If three British astronomers are right, they have discovered the first planet outside the solar system. The irony is that the planet wasn't found the way everyone expected it would be.

No orbiting speck of light reflected the glare of its star — and certainly no mysterious geometric patterns concealed in radio codes or old "Honeymooners" programs came beaming back from some distant civilization. Instead, the object was found by regular changes in the electromagnetic "ticking" emitted by its home sun, a pulsar only 30 kilometers across.

The story of this enigmatic object began in 1985, when astronomer Andrew Lyne discovered pulsar 1829–10 in a survey that also uncovered 39 other pulsars. (Pulsars are neutron stars, the super-dense remnants of large stars that have exploded as supernovae.)

The Best Black Hole in the Galaxy

by Ken Croswell, March 1992

Does the binary system A0620–00 host the best black hole candidate?

On Earth, black holes are everywhere. The national debt is a black hole. The savings-and-loan mess is a black hole. A friend of mine recently claimed his graduate thesis was also a black hole. "It sucks up all my time, all my energy, all my happiness," he said. "And there's no escaping it." In our Galaxy, however, black holes are much harder to find. For most of the last twenty years, astronomers had good evidence for only one stellar black hole in the entire Galaxy: a source of X rays in the constellation Cygnus called Cygnus X-1.

Now, though, astronomers have uncovered a much better candidate for a black hole in our Galaxy. It lies in the constellation Monoceros some three or four thousand light-years away and bears the prosaic name A0620–00. The A refers to Ariel V, the X-ray satellite that first detected the object, and the numbers refer to the object's right ascension and declination.

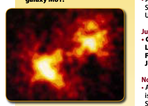
1993-1997: Bright comets thrill observers

Comets Hale-Bopp and Hyakutake dazzle skywatchers.

1993

- **The first of the twin 10-meter Keck telescopes on Hawaii's Mauna Kea is completed.**

March:
- **A supernova is found in galaxy M81.**



May:
- The 25th annual Riverside Telescope Makers Conference is held in Big Bear City, California.

August:
- *Astronomy* celebrates its 20th anniversary with a survey of astronomers in the feature "What's Next for Astronomy," by David Eicher.

December:
- An ambitious servicing mission repairs the Hubble Space Telescope.

1994

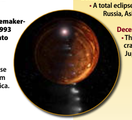
- Autostar, the first computerized go-to system for commercial scopes, is introduced by Meade.

April 2:
- Amateur astronomers find a supernova in the Whirlpool Galaxy (M51).

May 10:
- An annular eclipse of the Sun passes over the United States.

July:
- **Comet Shoemaker-Levy 9 (D/1993 F2) slams into Jupiter.**

November 3:
- A total eclipse is visible from South America.



1995

January:
- ***Astronomy* releases its first special edition, *Observer's Guide 1995*, which is published annually through 2006.**

August:
- *Astronomy* launches its web site, Astronomy.com

October 24:
- A total eclipse is visible from Russia, Asia, and Indonesia.

December 7:
- The Galileo spacecraft arrives at Jupiter.

1996

January 17:
- Astronomers announce the discovery of exoplanets in the constellations Ursa Major and Virgo.

March:
- **Comet Hyakutake (C/1996 B2) thrills observers with its long tail.**

August 6:
- Scientists announce possible microfossils in martian rock.

November:
- Bonnie Bilyeu Gordon becomes the editor of *Astronomy*.

December 20:
- Carl Sagan dies.

1997

January 17:
- Clyde Tombaugh, discoverer of Pluto, dies.

March:
- **Comet Hale-Bopp (C/1995 O1) dominates the sky.**

July 4:
- Mars Pathfinder lands on and explores the Red Planet.

July:
- ***Astronomy* is redesigned and adopts images that completely fill its covers.**

September 11:
- Mars Global Surveyor reaches Mars.

October 15:
- Cassini is launched toward Saturn.

The Age Paradox

by Ray Jayawardhana, June 1993

In 1997, Hubble provided a reliable age for the universe. Before this, some astronomers argued the universe seemed younger than the oldest stars in the Milky Way.

Cosmologists say the universe may be 8 to 15 billion years old. Stellar astronomers disagree. They say the oldest stars are much older, perhaps 16 to 19 billion years old. Because the oldest stars can't be older than the universe in which they lie, this age paradox presents a thorny problem for astronomers.

Resolving the age paradox is vital to understanding how the universe formed and evolved, but astronomers are having difficulty pinning it down.

Either the galactic distance scales used to find the age of the universe or the stellar evolution models used to find stellar ages must be wrong. Or perhaps both sets of data have flaws, as recent evidence suggests. Uncovering the flaws will provide astronomers with new information about how stars age, the distance to galaxies, and the expansion of the universe. Of the two ages, the age found from galactic motions, the cosmological age, is harder to determine.

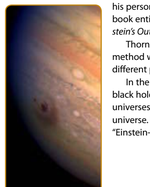
The End of the Line

by David J. Eicher, August 1994

Then-Associate Editor David Eicher explained how to observe the aftermath of Shoemaker-Levy 9 impacts.

Sentenced to destruction by wandering into Jupiter's gravitational embrace, the fragmented Comet Shoemaker-Levy 9 will meet its doom between July 16 and 22. One by one, its 21 major and thousands of minor pieces will slam into the cloudtops of Jupiter and vaporize with a force of up to 10 trillion tons of TNT. The event was ordained by the comet's capture by Jupiter about a century ago and subsequent fracture in 1992. Only in March 1993 did planetary scientists Gene and Carolyn Shoemaker and David H. Levy discover the comet and enable astronomers to determine its peculiar history.

The event will be the first of its type ever witnessed (see "All Eyes on the Comet Crash," June 1994).



Shoemaker-Levy 9 impact site

Of Wormholes, Time Machines, and Paradoxes

by J. Craig Wheeler, February 1996

Wheeler examined whether time travel is more science than science-fiction.

The latest chapter in physicists' attack on time travel arose from a work of science fiction. In the original version of Carl Sagan's novel *Contact*, he invoked a means of interstellar travel left by an ancient civilization for Earthlings to discover. Effectively, he wanted his passageway to be a black hole, where you flew into the event horizon and emerged — elsewhere. Sagan sent the draft of the book to his friend and colleague, Kip Thorne. Thorne, a physicist at Caltech, is one of the world's experts on black holes. In fact, he has written his personal version of this story in a recent book entitled *Black Holes & Time Warps: Einstein's Outrageous Legacy*.

Thorne realized that Sagan's proposed method was flawed. The solution required both different physics and more imagination.

In the solution for Einstein's equations for a black hole, a passage can exist between two universes or between two parts of the same universe. Physicists call such a structure an "Einstein-Rosen" bridge.

Top to bottom, left to right: NASA/JPL; ISAS, NASA, Y. Kohmura; *Astronomy*; NASA; Hubble Space Telescope Jupiter Imaging Team; Jason Ware; Michael Stecker; *Astronomy*

1998-2002: Cosmology's big surprise

Astronomers find evidence that suggests the existence of dark energy.

1998

- **Astronomers on the Supernova Cosmology Project and the High-z Supernova Search Team find the expansion of the universe is accelerating, suggesting the existence of a mysterious force called dark energy.**

February 26:
- A total solar eclipse is visible from the Caribbean.

March:
- *Astronomy* publishes a special issue featuring anaglyph composite images with 3-D glasses included.

November 20:
- **The first International Space Station section heads into orbit.**

1999

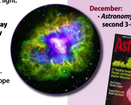
January 12:
- On Mauna Kea, Hawaii, the 8.3-meter Subaru Telescope achieves first light.

July 23:
- **Chandra X-ray Observatory is launched.**

August 11:
- A total solar eclipse is visible from Europe and Asia.

October:
- The 9.2-meter Hobby-Eberly Telescope comes on line in the Davis Mountains of West Texas.

November:
- **The Leonid meteor shower puts on a stormy show, impressing observers with a rare, highly active display.**



2000

November 2:
- The first resident crew enters the International Space Station.

December:
- *Astronomy* publishes a second 3-D issue.

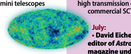
2001

- Observations begin with twin 8.1-meter Gemini telescopes in Hawaii and Chile.

June 30:
- **Wilkinson Microwave Anisotropy Probe is launched.**

June 21:
- A total eclipse cuts across Africa.

November:
- Once again, the Leonid meteor shower puts on a stormy show.



2002

- Meade is the first to offer ultra-high transmission coatings for commercial SCTs.

July:
- **David Eicher becomes editor of *Astronomy*. The magazine undergoes a redesign and takes an editorial direction with a balance of science journalism and observing information for all levels of skywatchers.**

- Eleven more moons are found orbiting Jupiter, bringing the planet's total to 39 satellites.

July 13:
- Astronomers announce the discovery of the first Jupiter-like planet found outside the solar system.

December 4:
- A total eclipse is visible from Africa and Australia.

Fast Forward, a Look at the Next 25 Years

by Richard Talcott, August 1998

This dialogue featured several leading scientists' opinions on the likelihood of earth-like planets in the Milky Way.

Alan Boss: I think it's pretty safe to predict that within the next 25 years we will have a pretty complete census of at least the more massive planets around most nearby stars …

Anne Kinney: My guess is you'll find that planets are ubiquitous, but planets like ours will be very rare. Never mind finding life or intelligent life, I mean just liquid water.

Alex Szalay: My feeling is that if there is a planet about the size of Earth and in a similar orbit, the probability is fairly high, tens of percent, that there will be liquid water on it.

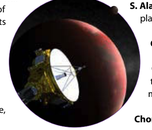
Bohdan Paczynski: There's more than one in our solar system. Europa (one of Jupiter's moons) supposedly has liquid water.

Planetary Oracles

by David J. Eicher, April 1999

Here, Astronomy *asked a group of planetary scientists whether Pluto should be classified as a planet.*

Heidi Hammel: Are you going to define planet for us?



New Horizons at Pluto

S. Alan Stern: Pluto's two planets.

Chorus: [laughter]

Carolyn Porco: It's two, it's two, it's two mints in one.

Chorus: [laughter]

Carl Pilcher: When this thing first surfaced, there were letters that came in from schoolchildren all over the country that read, "Please, please, don't change Pluto from being a planet!" This is really counterproductive.

Porco: Brian Marsden wants to give it an asteroid number.

Celebrating the Galactic Millennium

by Greg Laughlin and Fred Adams, November 2001

As we entered a new millennium, two authors forecast the future of the galaxy.

The fireworks have ended; the champagne has run dry. Whether you followed the popular shell in January 2000, or adhered to the purist definition and popped the corks in January 2001, the turning of the millennium has come and gone. If we adopt an astronomical perspective, however, a much larger and more distant celebration remains on the schedule — the Galactic Millennium. Just as Earth and the other planets orbit the sun, the solar system orbits the center of the Milky Way Galaxy. What will the solar system, the galaxy, and the universe look like when enough time has elapsed for the sun to make a thousand circuits around the Milky Way? How will the galaxy evolve over this enormous stretch of time? Although it is reasonably likely that we — the human race — won't be around to witness the ball drop, it is hard to resist speculation into the millennial future.

Top to bottom, left to right: University of Chicago; NASA; Caltech; *Astronomy*; Wally Pacholka; New Horizons art: JHUAPL/SwRI; WMAP Science Team; *Astronomy*: William Zuback

2003-2008: Exploring the solar system

The age of robotic spacecraft has transformed planets into new worlds.

2003

February 1:
- **Space shuttle Columbia breaks apart during reentry, killing its crew of seven.**

March:
- *Astronomy* undergoes a redesign that covers all aspects of the science and hobby more effectively.

August:
- Mars is big and bright at opposition; a special August issue covers the event.

August 25:
- The Spitzer Space Telescope is launched.

September:
- Special collector's edition 30th anniversary issue profiles *Astronomy*'s past, present, and future.

December 24:
- Mars Express arrives at Mars.

2004

- Go-to scopes make finding celestial objects easier and allow more observing time.
- The integration of personal computers with scope drives and CCDs begins.

January:
- **Rovers Spirit and Opportunity begin operations on Mars.**

March 2:
- ROSETTA launches toward Comet Churyumov-Gerasimenko.

June 8:
- **A rare transit of Venus is seen best from Europe, Africa, and Asia.**

July 1:
- Cassini enters Saturn's orbit

August 3:
- MESSENGER launches toward Mercury.

2005

January 14:
- Huygens probe descends through Titan's atmosphere.

February:
- *Astronomy* publishes a special issue celebrating Albert Einstein and relativity's centennial.

April 8:
- A total eclipse covers the South Pacific.

August 12:
- The Mars Reconnaissance Orbiter launches toward Mars.

September:
- In South Africa, the 11-meter Southern African Large Telescope begins science operations.

- **Hayabusa spacecraft arrives at asteroid Itokawa.**

October:
- On Mount Graham, Arizona, the 8.4-meter Large Binocular Telescope achieves first light.

2006

January 15:
- New Horizons launches toward Pluto.
- **Stardust returns to Earth with samples from Comet Wild 2.**

March 10:
- The Mars Reconnaissance Orbiter enters martian orbit.

March 26:
- A total eclipse is visible from Africa, Europe, and Asia.

April 11:
- Venus Express arrives at Venus.

May:
- *Astronomy* special edition, *Atlas of the Stars*, is published.

October 27:
- COROT extrasolar planet finder is launched.

2007/2008

January 2007:
- **Comet McNaught (C/2006 P1) is briefly visible as a bright object in twilight for Northern Hemisphere viewers.**

May 2007:
- *Astronomy* special edition, *50 Greatest Mysteries of the Universe*, is published.

November 2007:
- ***Astronomy* redesigns and improves its web site.**

March 2008:
- *Astronomy* special edition, *100 Most Spectacular Sky Wonders*, is published.

June 2008:
- ***Astronomy* special edition, *Extreme Weather*, is published.**

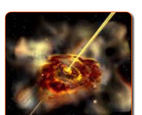
August 2008:
- Astronomy celebrates its 35th anniversary with a special issue.

Quasars Explained

by William Keel, February 2003

Astronomers identified the first quasar in 1963. Here's what we've learned about the most distant objects in the universe.

Even now, the very word "quasar" carries a buzz. It's mysterious and exotic. No doubt that's why quasar has been used as a brand name for TV sets, software, publishing companies, consulting firms, diamond brokers — even a bicycle.



Heart of a quasar

But what about the real thing? Are the objects themselves still mysterious and exotic? By now astronomers have studied them and their relatives for four decades. Has our understanding of quasars reached the maturity we associate with turning 40? Mature or not, the picture has grown much clearer — and, paradoxically, both simpler and more complex.

Relativity's infinite beauty

by James Trefil, February 2005

A century after Einstein published his revolutionary papers outlining his special theory of relativity, Trefil explained why physicists have embraced it.

Relativity has always been the odd man out in the sciences. In the general course of affairs, scientific ideas change slowly. Data challenging the old view starts to accumulate, then gets debated and worried about until, finally, kicking and screaming, scientists are dragged into a new way of looking at the world. With relativity, though, it was different. A young clerk in the Swiss patent office named Albert Einstein published a paper that was mainly about philosophy. When it appeared, scientists dispensed with their usual arguments about data and took the new ideas to heart.

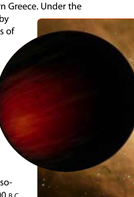
A big reason for that reaction comes from the fact that relativity is beautiful. I know that seems like a strange word to apply to what is, after all, a mass of equations, but that's the way physicists perceive it.

The new search for distant planets

by Geoffrey W. Marcy, October 2006

With the count of exoplanets reaching more than 200, how do astronomers hunt for worlds beyond our solar system?

For centuries, friends have gathered for lunch and conversation at outdoor cafés in northern Greece. Under the hot Sun, surrounded by appetizers and rounds of ouzo, conversations have often meandered toward the heavens, sparking heated debates about the existence of other fertile worlds. If those worlds also harbor citizens, might they also gaze toward the stars? Such café philosophers flourished in 400 B.C., when Democritus taught his students about the possibility of other habitable worlds of great diversity, and of the likelihood of life on them.



Exoplanet

Top to bottom, left to right: CNN; D. Kiselman/Institute for Solar Physics; Quasar art: A. Simonnet, Sonoma State University, NASA Education and Public Outreach; NASA/JPL-Caltech/Cornell University; ISAS, JAXA; NASA/JPL; Rob McNaught; *Astronomy*; Exoplanet art: NASA/JPL

— *Continued from page 44*

the horizon 20 minutes after sunset. It will be a challenge to see unless you have a perfect sky and a flat western horizon. After it passes 1° north of Regulus August 9/10, Mercury (at magnitude –0.7) lies 4° to Venus' lower right August 12.

Venus and Saturn appear closest August 13. The two planets then lie less than 1 Moon-width apart. Mercury joins the two between August 14 and 16. Over these 3 nights, this planetary trio presents a changing triangle. However, the group stands only about 5° high in the western sky 20 minutes after sunset, and the sky remains bright.

Although Venus will be relatively easy to spot, Mercury (at magnitude –0.5) and Saturn (at magnitude 0.8) will require binoculars. If you have a great sky and a flat horizon, Mercury will pop into view with the unaided eye before it sets. If you're lucky, Saturn may, too.

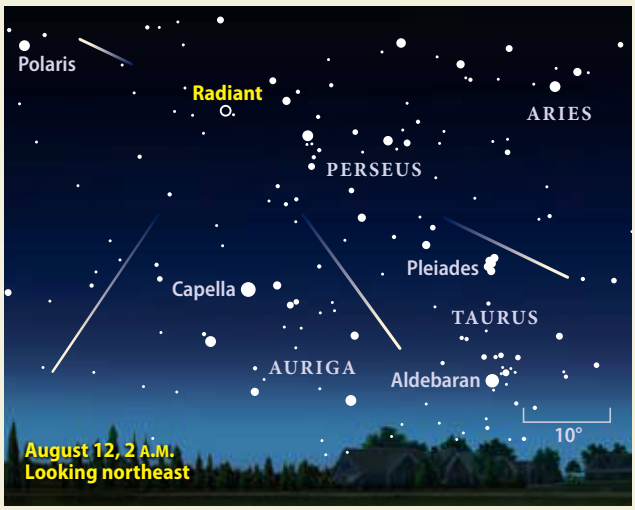
Mercury continues to chase Venus as their easterly motions carry them away from Saturn. On August 19, Mercury appears 1° directly below Venus as both planets continue to hug the horizon. By month's end, their separation increases to 3°.

While all this activity goes on, **Mars** lingers more faintly and at a higher altitude. It appears to acquire a moon August 14, when the 4th-magnitude star Beta (β) Virginis lies nearby. The faint (in twilight) star comes within 5' of Mars — look at the pair with low magnification on a telescope.

As August winds down, Mars prepares to receive visitors. On the 31st, observers will witness the month's second planetary trio — this one with Mars, Venus, and Mercury. Ruddy Mars stands 6° to the upper left of brilliant Venus, and Mercury lies between the two and slightly lower. The three planets will

Martin Ratcliffe *provides professional planetarium development for Sky-Skan Inc.* **Alister Ling** *is a meteorologist for Environment Canada.*

Meteor **watch**



Perseid meteors will rain down when this annual shower peaks before dawn August 12. Expect to see 60 to 90 meteors per hour under a dark sky after the Moon sets in the early morning. *Astronomy*: Roen Kelly

A Hero's welcome return

The most famous meteor shower of all peaks the morning of August 12. The Perseids result when Earth runs into debris ejected over the eons by Comet 109P/Swift-Tuttle. With warm weather typical this time of year, many observers camp out for the event.

Under ideal conditions, you may catch up to 90 meteors per hour at the peak. (If it's cloudy August 12, look for a decent show a day or two before and after.) The best time to view the Perseids comes after the gibbous Moon sets, around 1:30 A.M. local daylight time the morning of the peak. Watch especially near dawn, because this is when the chances of seeing a fireball are highest. Our view at dawn is head-on into the meteor stream, so the debris' impact velocity with Earth is higher and meteors tend to be brighter then.

Rising **Moon**

Cradled near the lunar pole

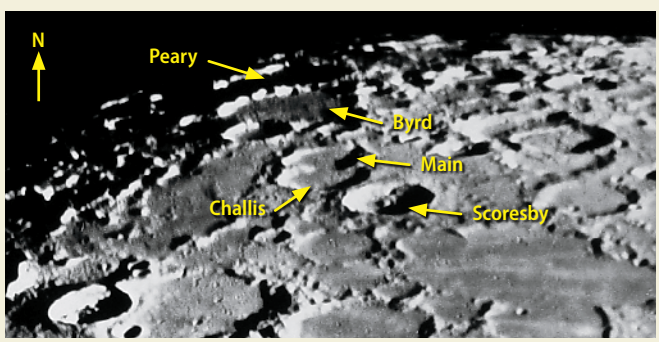
A First Quarter Moon delivers instant gratification when you slowly scan the terminator — the dividing line between day and night on the lunar surface. But if you're up for a little adventure, then you'll need a chart and some planning before trekking to the north pole.

The timing has to be right. Because the Moon's orbit is not perfectly circular, earthlings see a bit more of one limb, then another, in a slowly shifting pattern called libration. Around first quarter phase this month, the north pole tilts toward us, so our expedition leaves August 8.

Astronomers named features close to the lunar north pole after the great explorers of past centuries. The two main craters are Byrd and Peary. When you first set eyes on the northern cusp, however, your gaze will be drawn a bit farther south, to the sharply defined elliptical crater Scoresby. It stands in darkness except for its prominent rim and western wall. Immediately north and closer to the terminator lie Challis and Main, each slightly smaller than Scoresby.

Tucked against the Moon's limb are three sunlit arcs: the northwestern walls of Byrd and Peary and, right on the cusp, the rim of Rozhdestvensky. Named for a Soviet physicist, this feature lies at 86° latitude — on the lunar farside! The insides of these craters lie in deep shadow, leaving us to view highly foreshortened rim segments.

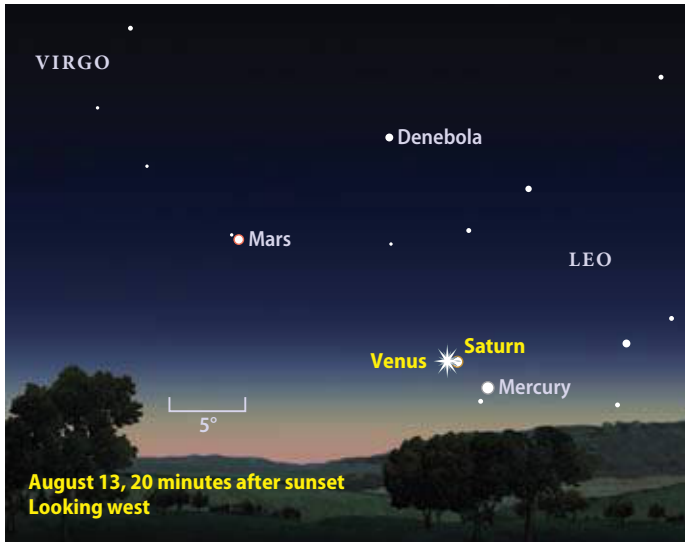
Another aspect to this viewing challenge is keeping your patience while atmospheric ripples distort delicate lunar features. Observers call this turbulence "seeing," which typically gets worse the lower you point your telescope.



Craters Byrd and Peary lurk near the lunar north pole. A favorable libration brings them and their surroundings into view around August's First Quarter Moon. *Consolidated Lunar Atlas*/UA/LPL

When to view **the planets**

EVENING SKY	MIDNIGHT	MORNING SKY
Mercury (west)	Jupiter (southwest)	Uranus (southwest)
Venus (west)	Uranus (southeast)	
Mars (west)		
Jupiter (south)		
Saturn (west)		



Multiple conjunctions grace this month's early evening sky, but the best of the bunch promises to be Venus' close approach to Saturn August 13. *Astronomy*: Roen Kelly

come closer to one another in early September.

Jupiter dominates the southern half of the sky all night. Gleaming at magnitude –2.6, it outshines every other point of light once Venus sets during twilight. As the Sun goes down August 1, the giant planet rises in the southeast, above the "handle" of Sagittarius' Teapot asterism. By month's end, Jupiter lies due south and at its highest altitude about an hour after sunset.

You'll need a telescope to view Jupiter's 45"-diameter disk. Unfortunately, the planet's low altitude combines with the lingering heat of the day to produce a fair amount of atmospheric turbulence, which will hinder detailed views. Still, Jupiter always has treats in store. The planet's two dark equatorial belts jump out immediately. Rest your eye on the scene, and finer, more subtle detail will pop into view during moments of steady seeing.

Jupiter's four bright moons — Io, Europa, Ganymede, and Callisto — continually dance around the planet and so take up different positions every night. If Jupiter weren't there, each of these moons would be bright enough to see without optical aid under a dark sky. Although Jupiter's brilliance prevents that, any telescope reveals these moons. They appear as bright "stars" aligned roughly with Jupiter's equator.

Often, one of the moons transits the face of the planet, almost disappearing except for the telltale dark shadow that accompanies it. At other times, the planet's disk hides a moon during an occultation.

Now that Jupiter is past opposition, its shadow projects into space to the disk's east. This means a moon's expected reappearance from behind Jupiter seems delayed because the planet's shadow still eclipses the moon. Dozens of these transits, occultations, and eclipses occur every week, although many occur in daylight. The result: A typical viewer will see only a few.

North American observers should try to watch the following events. On August 11, Ganymede begins to transit Jupiter's disk at 11:29 P.M. EDT. Three hours later, at 2:38 A.M. the following morning, Ganymede's shadow first

Comet search

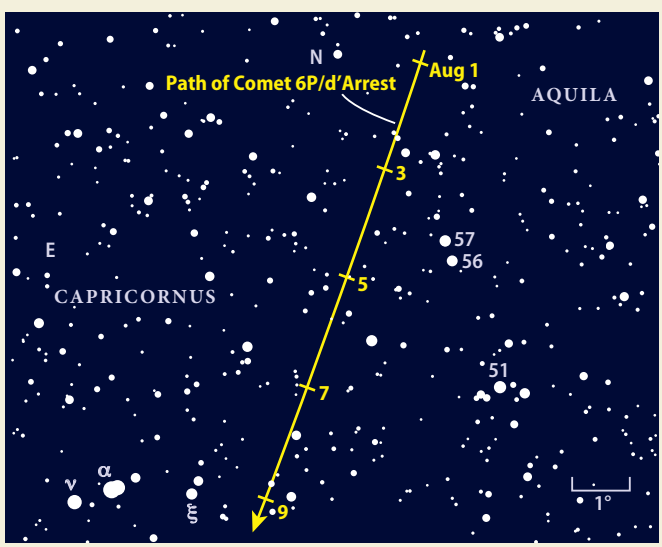
A pelting of cotton puffs

Topping a slew of August comets, periodic visitor 6P/d'Arrest dives from Aquila past the 3rd-magnitude double star Alpha (α) Capricorni into the obscure southern constellation Microscopium. Astronomers don't expect d'Arrest or any other comet this month to glow bright enough to see through binoculars. In short, this means you'll need a dark country sky to see any of them well. Observe before August 6 or after the 23rd to avoid moonlight.

At 10th magnitude, d'Arrest will be as tough to view as the faintest Messier galaxies in Virgo. With a 6-inch telescope, you may have trouble detecting its soft, diffuse glow. Bump up the power past 100x to darken the background sky, and use a dark hood or towel over your head to further cut stray light.

In 1968, d'Arrest passed close enough to Jupiter that the planet's gravity shortened its loop. The comet's closest point to the Sun now lies just outside Earth's orbit. According to comet observer and historian Gary Kronk, d'Arrest has produced a 2-magnitude outburst before — perhaps we'll get lucky and see another one.

If you're pulling an all-nighter, check out the brighter dawn dustball C/2007 W1 (Boattini). It slides northwest through the hockey-stick figure of Aries the Ram.



Comet 6P/d'Arrest races southward throughout August. Northern observers have their best shot at the 10th-magnitude fuzzball during the month's first 10 days. *Astronomy*: Roen Kelly

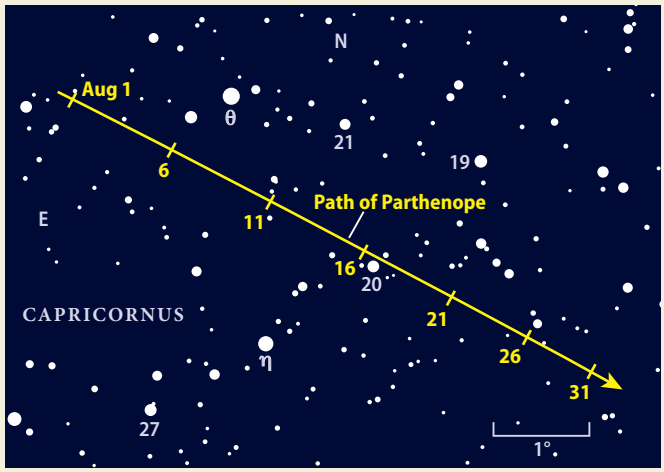
Siren song for the Sea Goat

You need a dark sky to see the constellation Capricornus the Sea Goat well. Its string of 3rd- to 5th-magnitude stars brings to mind an elegant necklace suspended to the Milky Way's left. From the suburbs, the constellation is almost lost except for the stars on either end. Jump in between to reach 4th-magnitude Theta (θ) Capricorni, this month's guidepost for the asteroid 11 Parthenope.

You may have an easier time finding this 95-mile-wide mountain of rock from the suburbs, because the background field won't be filled with oodles of faint stars. The stars are outliers of our galaxy's hub. Glowing at 9th magnitude, Parthenope outshines most of its nearby competitors, which should give you confidence identifying it using the chart at right. Just to be sure, make a quick sketch of the field and come back a night or two later. Parthenope is the point of light that moved.

Just a day after the August 16 Full Moon, our target slides directly between 20 Cap and an 8.4-magnitude star that lies 11' away. Over the course of an evening, you should notice the asteroid's movement.

Although it has a low number, 11 Parthenope didn't turn up until 1850 — 49 years after 1 Ceres. Italian astronomer Annibale de Gasparis picked the proverbial needle out of the celestial haystack by comparing what he saw through a telescope to star positions recorded on his charts. He chose the name Parthenope because, in Greek mythology, his home city of Naples was founded by this siren of the sea.



Asteroid Parthenope reaches opposition this month among the stars of Capricornus. It peaks at 9th magnitude and should be easy to find through a small telescope. *Astronomy*: Roen Kelly

touches the disk's eastern side. Just 4 minutes later, Ganymede itself slides off the disk's western edge.

On August 21/22, Io slips behind Jupiter's disk while Callisto's shadow crosses the planet's northern hemisphere. Io disappears at 11:35 P.M. EDT August 21. It reappears 3 hours later, at 2:49 A.M. EDT, following an eclipse. Europa then lies east of Jupiter, and Io reappears between Europa and the planet's limb. Callisto's shadow leaves Jupiter's disk at 2:27 A.M. EDT. Events involving Callisto are rare because it lies far from Jupiter. The moon takes a leisurely 16.8 days to revolve around the planet and return to the same relative position.

The second-largest dwarf planet — at least so far — is well-known **Pluto**. At 14th magnitude, it glows faint enough to be a challenge even in modest telescopes. Pluto lies less than 2° west of a convenient guidepost: the 6th-magnitude star 6 Sagittarii.

Neptune reaches opposition and peak visibility August 15. It resides in Capricornus, one constellation east of Jupiter. Once Jupiter passes the meridian, grab your binoculars and search for Neptune. This 8th-magnitude planet lies 2.5° northwest of 3rd-magnitude Delta (δ) Capricorni. Three obvious stars lie north of Delta, the brightest being 5th-magnitude 42 Cap. Neptune passes 9' south of this star August 12.

Turn your telescope on Neptune, and you'll see a disk just 2.4" across. The most noticeable aspect of this disk is its distinctive blue-gray hue. Methane in Neptune's thick atmosphere absorbs red light from the Sun, resulting in the bluish color.

Head one more constellation farther east to find this month's final planet, **Uranus**. It lies in Aquarius and appears high in the southern sky after midnight. Binoculars easily reveal this planet, which glows at magnitude 5.7. To locate it, start with the 4th-magnitude star Phi (ϕ) Aquarii in the constellation's northeastern corner. It lies south of the Circlet asterism of Pisces. Place this star in the lower right of your binocular field, and you should see Uranus 5° to the east-northeast. A telescope will show a blue-green disk that spans 3.7".

Many observers will trek across the globe to observe one of nature's grandest spectacles: a total eclipse of the Sun. On August 1, those along a narrow path that starts in northern Canada and makes its way across Greenland, Russia, Mongolia, and China, will see darkness come at midday. The eclipse track passes directly over the Siberian city of Novosibirsk. For more eclipse-viewing details, see "Get ready for summer's total solar eclipse" in the July issue.

Two weeks later, on August 16, skywatchers in Europe, Asia, and Africa will be in prime position to view a deep partial lunar eclipse. At maximum eclipse, which arrives at 21h10m Universal Time, 81 percent of the Moon is immersed in Earth's dark umbral shadow.

Earth's shadow creeps across the Moon's face for those in the Eastern Hemisphere August 16. At maximum, 81 percent of the Moon will be in our planet's dark shadow. Anthony Ayiomamitis

The next wave

10 rising stars of astronomy

The past 35 years of astronomy have been stunning. Here are up-and-coming astronomers likely to blaze new trails in coming decades. **by Daniel Pendick**

Astronomy published its first issue in August 1973. In the intervening 35 years, astronomers have enlarged our understanding of the universe to a degree unimaginable at the time. Some of these astronomical stars have even become household names.

For example, in 1974 physicist Stephen J. Hawking gave the world the theoretical basis for Hawking radiation, which allows black holes to lose mass and shrink. But even as an undergraduate in the late 1950s, Hawking displayed an intense, searching intelligence — a quality not lost on his teachers and fellow students.

As Robert Berman, Hawking's undergraduate physics tutor, later said of the budding scientist's final exams, "The examiners then were intelligent enough to realize they were talking to someone far more clever than most of themselves."

Every new generation of "bright young things" in astronomy includes extraordinary individuals like Hawking. So, for this anniversary issue of *Astronomy*, we asked some senior astronomers who they thought were the rising stars in their field today.

Who are the exceptional scientists, early in their careers, already making important contributions — and likely to continue doing so? The faces you see on these pages are the result of this somewhat unscientific poll.

Daniel Pendick *is an associate editor of* Astronomy.

This group of rising stars is eclectic. Some are barely out of graduate school and shopping for a permanent position, while others are professors shepherding flocks of eager young students who want to work with them.

Most have won the most prestigious recognition and awards in the astronomy world, including the Hubble, Spitzer, Caltech, and Carnegie fellowships; the Pierce and Warner prizes; and (for women) the Annie Jump Cannon Award. Some have won multiple academic honors and prizes.

You will see these names again in the pages of *Astronomy*.

Their interests range from the evolution of icy moons to the birth of the first galaxies. We tried to select a group of people whose work represents a diverse spectrum of astronomical research.

It was fascinating to speak to these brilliant people and hear about their future plans, but frustrating to stop at only ten scientists. There are many rising stars in the firmament of professional astronomy — too numerous to fit in this somewhat narrow snapshot of the field.

Astronomy subscribers will find information about other astronomical up-and-comers in a special web extra on Astronomy.com, as well as more detailed information on the astronomers profiled in the magazine.

One thing is likely: You will see these names again in the pages of *Astronomy*. We can only hope that, in the next 35 years, these exceptional scientists won't figure out all the big questions and put us out of business.

Ana Porinoy/NASA/Dana Berry

JOSHUA BLOOM
bursts of knowledge
University of California at Berkeley

In 2005, Joshua Bloom, then 31, led the team that pinpointed the source of a short gamma-ray burst (GRB) to an old, red galaxy. This observational feat provided a critical clue to the probable cause of short GRBs: the collision of two neutron stars.

Bloom compares the analysis of a GRB to a crime scene investigation. "If you blow something up over the course of a second, what you have left is this forensics scene," he says. "You have to look for the fingerprints of something that isn't there anymore."

To understand GRBs, it will be critical to train as many telescopes as possible on their fleeting afterglows as soon as possible. Bloom is banking on help from robotic telescopes.

His team already uses the world's largest robotic infrared telescope, PAIRITEL, to observe the early light from GRBs. He created a programming language for robotic telescopes that allows the instruments to automatically distribute GRB sightings to other telescopes.

Bloom's hope is to get a wide range of instruments focused on GRBs after they flash to life — and without necessarily waking anybody up. Robots may largely replace the telephone calls and e-mails astronomers use to build informal observing networks.

For Bloom, observing GRBs with robotic telescopes is an ideal combination of science and technology. "I was much more of a generic science and math kid who enjoyed computer programming. But in college, I came to see astronomy as a beautiful confluence of my many interests."

Francois Rogez / NASA/JPL/SSI

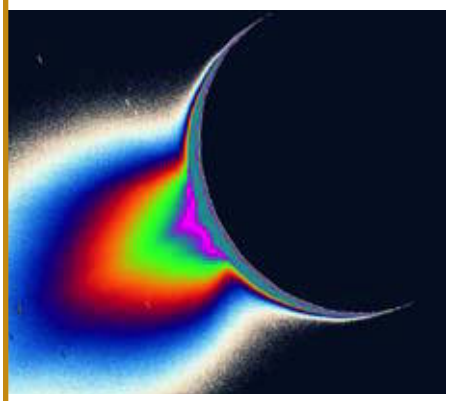
JULIE CASTILLO-ROGEZ
icy moons
Jet Propulsion Laboratory

Julie Castillo-Rogez, 33, develops mathematical models to explain the evolution of icy moons. She starts at the very beginning of the solar system to explain processes currently shaping bodies such as Saturn's Enceladus.

For example, the model considers the effect of radioactive isotopes that may have been present in these objects after they formed. The rapid decay of these isotopes added a lot of heat to the interior of the icy moons, allowing some to form deep, watery oceans.

She also has used her model to look closely at Saturn's moon Enceladus and the watery plume that erupts from its south polar region. "One big question about Enceladus is how it got so warm," Castillo-Rogez says.

She and fellow Jet Propulsion Laboratory scientist Dennis L. Matson recently used the model to determine that Enceladus must have formed early — within the first 5 million years of the solar system's birth.



NASA/JPL/Space Science Institute

Julie Castillo-Rogez's research may help reveal the source of the heat that powers water geysers on Saturn's moon Enceladus, shown here backlit by the Sun.

Mary Jo Robertson (UCLA)/ NRAO/AUI & ALMA/ESO/NRAO/NAOJ

STEVEN FURLANETTO
cosmic storyteller
University of California, Los Angeles (UCLA)

Steven Furlanetto, 31, was not the type of kid to gaze at the sky through telescopes. But in college, he discovered that astronomy combined physics and history. Furlanetto found the combination irresistible.

"Cosmology is sort of like history on a very large scale," he says. "You're trying to uncover the story of the universe. So it was a natural fit for me to head in this direction."

"Cosmology is like history on a very large scale. You're trying to uncover the story of the universe."

— Steven Furlanetto

Furlanetto is doing important work on the gas and dust that occupies the vast spaces between galaxies — the intergalactic medium (IGM). In the near future, he will probe the IGM using a radio telescope, the Murchison Wide-Field Array (MWA), now under construction in Australia.

The MWA will tune in to hydrogen atoms in the IGM emitting at the 21cm wavelength. On this cosmic "channel," it's possible to hear signals from the time when the first stars blazed to life.

Furlanetto will use computer models to interpret the signals radio telescopes collect on the IGM, such as the rate and timing of the reionization and what may have caused it. "This area is exploding right now," Furlanetto says.

Jim McCulty (OSU)

SCOTT GAUDI
exoplanet hunter
Ohio State University

Blame it on Scott Gaudi's second-grade teacher for making him into an exosolar planet hunter. The teacher told Scott to memorize the (then) nine planets. So he went home and picked up a *National Geographic* book about the universe. He was hooked.

"I read the book cover to cover and announced to my parents that I was going to be an astronomer," Gaudi says. "They patted me on the head and assumed the next day I was going to be a fireman."

They were wrong. In fact, Gaudi, 34, has discovered his own planets. He led a team that found a solar system that resembles a scaled-down version of ours. Gaudi and his team have discovered seven planets so far, and have contributed observations on two more.

The team found the planets with a technique called gravitational microlensing. Astronomers have mostly used gravitational lensing to study distant galaxies and search for the universe's missing "dark" matter.

Some scientists doubted that the technique would succeed in detecting exoplanets. Gaudi thought otherwise, and he was willing to do the work to prove it. The team reported its findings February 15, 2008, in *Science*.

It was a coup in Gaudi's young career. "I heard a fair amount of naysaying, people saying this technique will never work, or it's not interesting," Gaudi says. "It's now not just detecting new planets, but providing fundamentally new information about extrasolar planets. So it's been a great step forward for me personally." And for astronomy, too.

Tom Cogill

KELSEY JOHNSON
super-star science
University of Virginia

Kelsey Johnson, 34, investigates the birth of super star clusters (SSCs), dense masses of hundreds of thousands to millions of young stars. Her enthusiasm for SSCs is quickly evident. "I love super star clusters," Johnson says. "They can provide insight into a huge range of astronomical phenomena."

Johnson and her colleagues were the first to use a radio telescope to study SSCs embedded in their gaseous birth clouds. She hopes studying them will help answer some of the most important questions about star formation. For example: "How does physical environment in a galaxy affect what kinds of stars form?" she says.

"I love super star clusters. They can provide insight into a huge range of astronomical phenomena."

— Kelsey Johnson

Star birth has even greater implications, Johnson believes. "Aside from gravity, star formation drives almost everything else in the universe. And we don't even understand it in our own galaxy, let alone the early universe where the physical conditions were dramatically different."

Ultimately, Johnson hopes that her research will shed light on star formation throughout the cosmos.

Fred Raslo / Tom Trower (NASA Ames Research Center)

VICKY KALOGERA
compact questions
Northwestern University

Vassiliki (Vicky) Kalogera, 37, does her astronomy in a box — the kind that encloses motherboards and hard drives. She uses computers to model the extreme processes that produce small, dense astronomical objects like black holes and neutron stars. The birth of such "compact" objects comes at the end of a star's life.

Kalogera tries to bridge the gap between what came before and what we see now. This requires the interplay of computing and observing. She works closely with observers, drawing from their data to feed her models. The modeling, in turn, allows her to suggest explanations and help observers interpret their observations

For example, Kalogera models the birth of black holes. Such events are so violent they send out disturbances in the fabric of space-time called gravity waves. The waves travel for long distances across the universe, like ripples on the surface of a pond.

A number of gravity observatories on Earth want to detect those ripples. But what type of signal should they expect to see from the formation of a black hole? Kalogera's modeling provides this much-needed guidance.

Kalogera's team is prolific, with many published articles in major journals. But it's not all about the numbers.

"The value of the group is not just the number of papers," Kalogera says. "It's the ability to pursue projects that require broad expertise that you can incorporate only through collaboration. One person working alone could not do some of the studies we are doing now in the group."

University of Hawaii (IfA)

LISA KEWLEY
a breath of fresh air
University of Hawaii, Manoa

Lisa Kewley studies oxygen abundance in galaxies to understand cosmic history. In 2006, by comparing galaxies at different distances, she calculated that most of the oxygen atoms we breathe formed between 5 billion and 12 billion years ago.

When presenting Kewley, 33, with the 2006 Annie Jump Cannon Award in Astronomy, the American Astronomical Society cited her work on understanding the spectra of light from galaxies, pioneering techniques for studying star formation, and her leading role in research on changes in the universe's chemical composition since the beginning of time.

Kewley is best known to other astronomers for theoretical modeling of starburst galaxies — galaxies undergoing a sharp spike of star formation. Her colleagues also appreciate the techniques she developed to speed up the interpretation of galaxy spectra. These "diagnostics" can save astronomers months of toil in creating — from scratch — the mathematical models required to interpret spectra.

Kewley also played a key role in developing an online tool called MAPPINGS: Modeling And Prediction in PhotoIonized Nebulae and Gasdynamic Shocks. MAPPINGS allows anyone in the world to interpret galactic spectra without having to own a big, powerful computer.

The model runs at the University of Hawaii. Pull-down menus allow a user to "set the dials" and plug in their data. Working astronomers use it. Some teachers even assign it to college science students as homework.

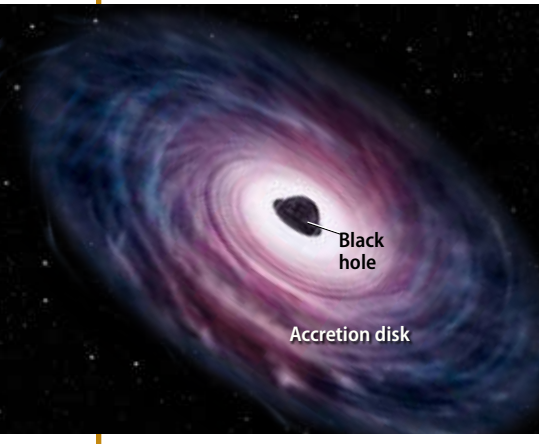
UC-Berkeley /NRAO/AUI

ELIOT QUATAERT
cosmic browser
University of California at Berkeley

Eliot Quataert, 34, likes the room that astrophysics offers. "I can think about a wide variety of problems, from how galaxies form to how gas falls into black holes and gives rise to bright bursts of radiation. That kind of breadth is very attractive."

Quataert is most well known for his work on the infalling, or accretion, of gas onto supermassive black holes in the centers of galaxies. At question is how gas gives rise to radiation near the black hole's event horizon, beyond which nothing, not even light, can escape. "In broad strokes we understand this process, but there are a lot of details that are not understood."

One of Quataert's ideas explains why supermassive black holes commonly have almost exactly one-thousandth the mass of their host galaxies. At that threshold mass, Quataert says, the black holes grow so large that their powerful radiation prevents fresh matter from accreting.



Astronomy: Roen Kelly

Eliot Quataert wants to learn more about the physics operating at the zone where matter spins into a black hole — the accretion disk.

Mary Jo Robertson (UCLA)/ NASA/ESA/STScI/HUDF team

ALICE SHAPLEY
time traveler
University of California, Los Angeles (UCLA)

Alice Shapley, 33, discovered the excitement of astronomy in fifth grade as she watched a filmstrip about the giant telescope at Palomar Mountain Observatory and new sightings of distant objects called quasars.

"The idea was that, by looking far away, you were looking back in time," she says. "Every time I thought about it, it sort of tweaked my interest."

Now, as an adult, vast distance has not discouraged Shapley's interest in the early universe. "Since grad school," she says, "I have focused on trying to understand the detailed physics and processes operating in distant galaxies, despite the fact that they are so faint and small and far away."

Shapley collects most of her data with the 10-meter Keck Telescope in Hawaii. A typical observing run lasts two nights, during which she images those faint galaxies for 1 to 2 hours.

The Keck allows Shapley to look at the early universe. But ultimately she's after the rest of the story, too. "I am interested in how the stars formed in these distant galaxies," Shapley says, "but also in how their chemistry evolved over time."

The rate of star formation was high in the early universe. Galaxies expelled vast amounts of gas and dust, enriching the intergalactic medium (space between galaxies) with elements. Radiation from young galaxies' stars also affected the intergalactic ecosystem.

Shapley wants to understand how all this chemical enrichment and radiation shaped the future evolution of the universe. Two nights at a time, she searches for the answers.

Becky Haycox/ NASA/ESA/Hubble Heritage Team (STScI/AURA)

TOMMASO TREU
dark matters
University of California, Santa Barbara

Tommaso Treu, 33, was a member of the large team that announced, in January 2008, the discovery of a rare beast. They found a double Einstein ring formed by the chance alignment of galaxies that bent light from a distant galaxy with their gravity. Such lineups are so rare that Treu says the team "hit the jackpot."

Treu is best known for his work on elliptical galaxies. He wants to understand the interplay of three ingredients in ellipticals: dark matter (invisible to conventional telescopes), normal matter (such as stars), and the supermassive black holes at their centers.

"The three components seem to 'know' about each other, although their physics is very different," Treu says. "Who was there first? How do the stars grow into the dark matter halos? Was the black hole the initial seed, or did it come later?"

Treu's work has helped to show that the basic construction process — the growth of a central black hole and the formation of stars and a dark matter halo — is over by less than half of the universe's 13.7-billion-year lifetime.

But smaller galaxies seemed to evolve for a longer time, until about the last 2 billion years. This doesn't fit with the standard story, where smaller galaxies collect into larger ones.

This leaves plenty of room for future research. "However, if that fails," Treu says, "theorists may need to go back to the drawing board."

Learn more about these and other rising stars in astronomical research at www.Astronomy.com/toc.

Your scope and the seven dwarfs

Surprisingly, even a small telescope can reveal these seven dwarf galaxies. **by Richard Jakiel**

NGC 205 in Andromeda orbits M31, but the interaction doesn't stop there. The giant spiral pulls material off its elliptical partner, forming a tidal tail visible through medium-sized telescopes from a dark site. Anthony Ayiomamitis

Observers love grand-design spiral galaxies and wacky irregulars. But dwarf galaxies are getting more notice these days. They are the smallest galaxies known — and the most populous group. Astronomers discovered most of them only in the past few decades. Far from being small static galaxies, many have interesting stories. I'll introduce you to seven standouts in this little-observed category.

Of the universe's billions of galaxies, we see giant ellipticals and pretty spirals over vast distances. Yet the far more numerous dwarf galaxies, just a few tens of millions of light-years from Earth, are so faint that they hide from view through even the largest telescopes. Our Local Group of galaxies contains at least 35 members, of which 30 are dwarf systems.

Strange satellites of M31

We'll start in the immediate area of the Andromeda Galaxy (M31). Small and highly concentrated, the compact elliptical galaxy **M32** (NGC 221) is the archetype of the rare and exotic ultra-compact dwarf (UCD). It has a brightness profile typical of a giant elliptical galaxy like Virgo A (M87), and its core is 4 magnitudes brighter than a typical dwarf elliptical or dwarf spheroidal galaxy.

Astronomers think M32 was the core of a loose spiral that ventured too close to its gigantic neighbor, which stripped away its outer regions. Astronomers recognize only a few galaxies of this type.

A more typical dwarf is **NGC 205**, another of M31's satellites. Its even illumination and modest core concentration typify the spheroidal galaxy class. But NGC 205 is hardly an ordinary galaxy.

Long-exposure images reveal a broad tidal tail of material being pulled off the smaller galaxy back toward the massive spiral. Under a dark sky, sharp-eyed observers can glimpse this plume even through a 4-inch telescope.

M32 in Andromeda is a rare example of an ultra-compact dwarf (UCD) galaxy. Sometime in the past, its larger companion — the Andromeda Galaxy (M31) — probably stripped away its outer layers. Adam Block/NOAO/AURA/NSF

Some irregular irregulars

A small, irregular galaxy, **IC 10**, is a Local Group member. American astronomer Edwin Hubble (1889–1953) referred to it as "one of the sky's most curious objects." IC 10 has an unusually large number of bright blue stars and, at 2.3 million light-years, is the nearest example of a starburst galaxy (one with an exceptionally high rate of star formation).

IC 10 also shares many characteristics of a blue compact dwarf, in which newborn massive blue stars dominate other types. You won't need a large telescope to observe it. IC 10 appears as an irregular

Richard Jakiel *has observed the deep sky for 30 years. He recently coauthored* Galaxies and How to Observe Them *(Springer, 2006).*

IC 10 in Cassiopeia is the nearest example of a starburst galaxy — one in which an extraordinarily large amount of star formation occurs. It lies only 2.3 million light-years away and glows at magnitude 11.2. Adam Block/NOAO/AURA/NSF

11th-magnitude glow about 1.5° east of Caph (Beta [β] Cassiopeiae).

Better-known is **Barnard's Galaxy** (NGC 6822). Discovered visually by American astronomer Edward Emerson Barnard (1857–1923) in 1881 through a 5-inch refractor, this low-surface-brightness irregular can be notoriously difficult to see through large-aperture scopes. In such instruments at high powers, it blends into the background.

Meet the seven dwarfs

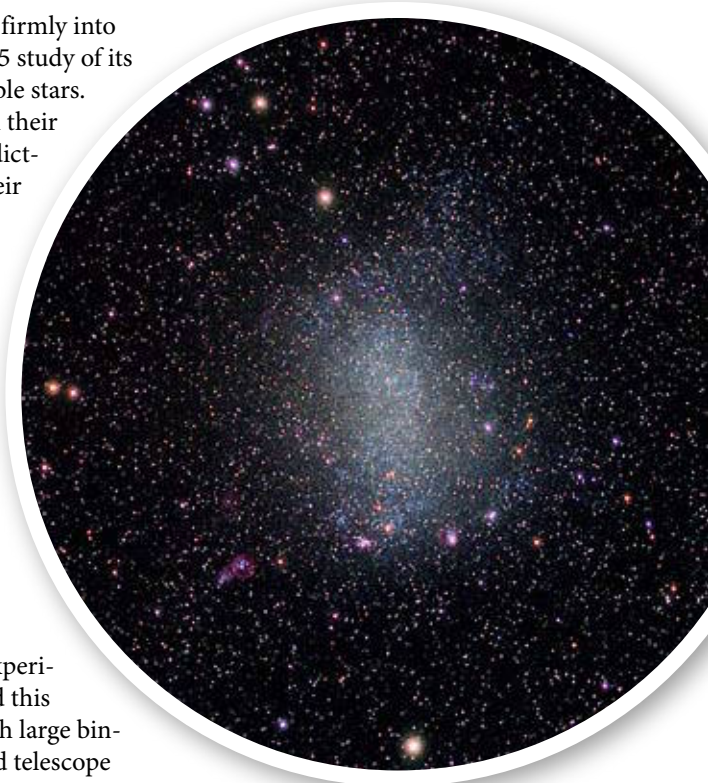
Object	R. A.	Dec.	Size
WLM	0h02m	–15°27'	11.1' by 3.8'
IC 10	0h20m	59°18'	6.3' by 5.1'
NGC 205	0h40m	41°41'	21.9' by 11'
M32	0h43m	40°52'	8.7' by 6.5'
Fornax Dwarf	2h40m	–34°27'	35' by 30'
SagDEG	18h56m	–30°33'	7.5° by 3.6°
Barnard's Galaxy	19h50m	–14°48'	15.5' by 14'

R. A. = Right ascension (2000.0); Dec. = Declination (2000.0)

Barnard's Galaxy stepped firmly into the limelight in Hubble's 1925 study of its population of Cepheid variable stars. These cosmic markers reveal their distances because of the predictable relationship between their periods of variability and their true brightnesses.

Hubble soon established NGC 6822's true extragalactic nature, making it the first object determined to lie far beyond the Milky Way's boundaries. The Andromeda Galaxy and the Pinwheel Galaxy (M33) would soon join Barnard's Galaxy as "island universes."

Observing Barnard's Galaxy isn't difficult — use low power at a dark site. Some experienced observers have spotted this magnitude 9.3 galaxy through large binoculars, and a good rich-field telescope certainly will get the job done. Several star-forming regions in the northern portion of the galaxy pop out through 10-inch or larger scopes. If you're



Barnard's Galaxy (NGC 6822) was the first object shown to lie beyond the Milky Way's boundaries. Despite its claim to fame, NGC 6822 is not easy to observe, so use low powers. Daniel Verschatse

The galaxy known as Wolf-Lundmark-Melotte (WLM) in Cetus combines the last names of its three independent discoverers. Use a medium-sized telescope and a wide-field eyepiece to observe this 11th-magnitude galaxy. NOAO

star-hopping, start at the planetary nebula called the Little Gem (NGC 6818), and then slowly move the telescope about 0.7° to the south-southeast.

Our third dwarf irregular galaxy, **Wolf-Lundmark-Melotte** (WLM), is perhaps best known for its unusual name. In 1909, German astronomer Max Wolf (1863–1932) discovered WLM photographically. In 1926, Swedish astronomer Knut Emil Lundmark (1889–1958) and Belgian-born British astronomer Philibert Jacques Melotte (1880–1961) independently discovered it.

Although WLM glows at a reasonably bright magnitude 11.2, its large size (11.1' by 3.8') gives it a low surface brightness that makes it difficult to observe. When star-hopping, start from Beta Ceti and work westward along a series of star chains. Use at least an 8-inch telescope to find this diffuse, elusive target.

The dwarf spheroidals

More than half of the Local Group's dwarfs classify as dwarf spheroidals. American astronomer Harlow Shapley (1885–1972) discovered the first representatives of this class in 1938. At first, he thought they were photographic defects, but later photographs through larger telescopes proved their extragalactic nature.

The brightest of these is the **Fornax Dwarf**, a diffuse ball of faint stars more than 600,000 light-years away. It has five globular clusters. They range from 12th to 16th magnitudes and are considerably easier to spot than the galaxy itself. The brightest is NGC 1049. The Fornax Dwarf's 8th magnitude is deceptive because it spreads over an area larger than the Full Moon. To observe this object, use a telescope/eyepiece combination with a wide field of view, and slowly sweep back and forth across the field looking for modest brightness changes.

The Fornax Dwarf makes a difficult target for visual observers because it measures almost 1° across. To observe this low-surface-brightness object, use high-power, tripod-mounted binoculars or a telescope-eyepiece combination that provides a wide field of view. Daniel Verschatse

Globular Cluster M54 belongs to the Sagittarius Dwarf Elliptical Galaxy (SagDEG), an object with such low surface brightness that it is unobservable through amateur telescopes. Lee C. Coombs

Our last object wasn't discovered until the early 1990s during a survey looking for cool giant stars in the Milky Way. The **Sagittarius Dwarf Elliptical Galaxy** (SagDEG) is the second-nearest galaxy to our own. The Milky Way is tearing this dwarf asunder, and its stars now occupy a 7.5° by 3.6° swath of the sky.

SagDEG has at least five globular clusters, of which magnitude 7.2 M54 is the largest and brightest. M54 ranks as the second most massive of the Milky Way's globular clusters (after Omega Centauri [NGC 5139]). M54 resides close to the dwarf system's core. Some researchers think the globular is SagDEG's core, although this assertion is controversial.

SagDEG's stars are too faint and spread out for amateurs to view through their telescopes. But M54 is a bright target and certainly the night sky's easiest extragalactic globular cluster. And who knows? By observing this object, you might be seeing a galaxy's core torn apart and cannibalized by the Milky Way.

For definition of terms, be sure to log onto www.Astronomy.com/toc

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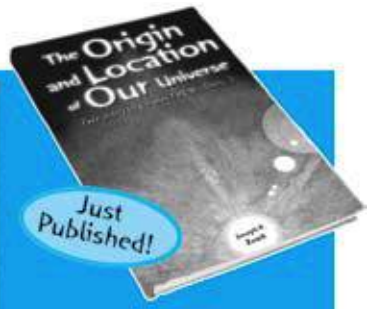

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Amateur astronomy's greatest generation

After World War II, the era of the personal telescope revolutionized stargazing.
by Michael E. Bakich

It all began at Stellafane. In 1926, the amateur telescope-making movement originated in Springfield, Vermont, at Stellafane, the local astronomy club's annual meeting. Jeffrey Hines

Amateur astronomy — the study of the sky without that pursuit leading to gainful employment — has enjoyed decades of popularity in America. From a less-than-auspicious beginning in the early 20th century, interest heightened following World War II when several companies began to market high-quality telescopes. Before that, almost all telescopes were hand-crafted.

The early 20th century

In the first half of the 20th century, observers with the appropriate mechanical skills opted to build their own scopes because the custom scopes of the day, although good, were expensive. A great increase in amateur telescope-making grew out of a 1921 article, "The Poor Man's Telescope," which appeared in *Popular Astronomy*.

The author was Russell W. Porter of Springfield, Vermont. His idea caught on quickly. Many astronomy clubs established workshops where members could meet to grind mirrors and lenses for homebuilt telescopes.

Articles in other publications also encouraged the growth of amateur telescope-making in America. In 1926, Porter's telescope-making club in Springfield established an annual meeting to share ideas and showcase members' work. Called Stellafane, the meeting continues to be held every July or August, and is the longest running astronomy convention in the world.

The 1940s and 1950s

After World War II, American amateur telescope makers benefited from a glut of postwar surplus optics. Enterprising handymen (at the time, almost all amateur astronomers were men) acquired mirrors, lenses, tubes, and motors to assemble impressive telescopes.

Not everyone who wanted to observe had the tools and talent to build a telescope. So by the end of the 1950s, four major manufacturers of amateur telescopes were in business.

The first, founded in the late 1940s, was Criterion Manufacturing Co., which sold Newtonian reflectors. In 1957,

Michael E. Bakich *is a senior editor of* Astronomy *and a lifetime amateur astronomer.*

Criterion began selling the Dynascope, a 6-inch f/8 Newtonian on a motor-driven equatorial mount. This model proved to be immensely popular, and Criterion produced it well into the 1980s.

Another event helped kick-start amateur astronomy: the founding of the Astronomical League. In 1941, 12 astronomy clubs ratified the new bylaws of the Amateur Astronomers' League of America. World War II intervened, and the League held its first meeting in July 1947.

The fledgling organization then counted 1,568 members. Its rolls have since swelled to more than 20,000 dedicated amateurs.

Let's party!

Besides astronomy club meetings, the most popular destinations for amateur astronomers are star parties, which typically occur under dark skies. Some dedicated observers travel thousands of miles to attend their favorites.

The most popular events, in terms of attendance, include the Grand Canyon Star Party (established in 1991), Oregon Star Party (1987), Texas Star Party (1979), and Winter Star Party (1984).

Need a new scope?

Many amateur astronomers happily classify themselves as equipment junkies. For them, now is the best time to be an observer. Telescopes, with optics featuring special coatings, are better than ever. Computer-controlled go-to drives, whose databases contain tens of thousands of objects, boast finding and tracking accuracy unheard of in years past. Cameras, accessories, and observing guides number in the thousands.

Several large conventions currently highlight equipment over observing. Stellafane was the first. In 1969, the Riverside Telescope Makers Conference (RTMC) followed in its wake. RTMC convenes each Memorial Day weekend near Big Bear City, California.

Another large "equipment fest" appeared in 1992, when the Rockland Astronomy Club of Suffern, New York, hosted the first Northeast Astronomy Forum & Telescope Show (NEAF). Today, NEAF attracts hundreds of astronomy vendors and thousands of visitors to its April shows.

This year, the organizers of RTMC announced a new international astronomy convention, the Pacific Astronomy & Telescope Show (PATS). The event will occur September 13–14, 2008, at Pasadena Convention Center, in downtown Pasadena, California. This show will feature astronomy and telescope oriented speakers, vendors, and workshops. Held during a Full Moon weekend, PATS will not conflict with any autumn star parties or club observing sessions. For more information, go to www.rtmcastronomyexpo.org/PATS.htm.

The Winter Star Party (WSP) occurs annually in the Florida Keys. The Southern Cross Astronomical Society of Miami is the host. WSP dates for 2009 are February 21 through 28. Maggie McKee

Russell W. Porter (1871–1949) was the man most responsible for promoting amateur astronomy in the first half of the 20th century. Caltech

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***Astronomy* magazine** first carried an ad for the Criterion Manufacturing Co. Dynascope in its third issue, October 1973. Many amateur astronomers purchased this telescope from 1957 through the 1980s. *Astronomy*: William Zuback

The Texas Star Party began in 1979 at Davis Mountains State Park. Event organizers schedule this popular event around the New Moon in April or May. Robert Reeves

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Coulter Optical began selling its 13.1-inch Odyssey 1 in 1980. This large-aperture Newtonian reflector helped popularize the Dobsonian mount. *Astronomy:* William Zuback

Hobby benchmarks

In addition to the mass-produced telescopes beginning in the 1940s, amateur astronomers can point to significant events that have moved the hobby forward. For example, in 1970, Celestron Pacific (now Celestron) of Torrance, California, introduced the first Schmidt-Cassegrain telescope. The orange-tubed C8 — Celestron's 8-inch version and the company's most popular size — revolutionized amateur astronomy. This design offered medium to large aperture (up to 14 inches), light weight (which aided portability), high-quality optics, and an f/10 focal ratio (which allowed observers to use high magnification), all at moderate cost.

Around 1967, former Vedantic monk John Dobson invented a simple mount for Newtonian reflectors. For more than a decade, he traveled around the country teaching others how to make his mount. In 1980, thanks in part to Coulter Optical, then of Idyllwild, California, the design became the most popular type of telescope mount.

The 13mm Tele Vue Nagler eyepiece debuted in 1980 and won wide acclaim among amateur astronomers. *Astronomy:* James Forbes

Coulter's first Dobsonian-mounted reflector was the Odyssey 1, a 13.1-inch f/4.5 telescope. This model, whose $500 price placed it far below any comparably sized instrument at the time, proved popular with observers. Coulter followed the Odyssey 1 with the Odyssey 2, a 17.5-inch f/4.5 instrument that delivered views of deep-sky objects never before seen by most amateur astronomers.

Other manufacturers picked up the excitement generated by the first large Dobsonian-mounted reflectors. Today, telescopes up to 30 inches in aperture feature Dobsonian mounts because of their ruggedness, simplicity, and low cost.

Not all amateur astronomy benchmarks involved inexpensive products. In 1981, Roland Christen created a "color-free" triplet objective lens, which his company, Astro-Physics of Rockford, Illinois, produced and sold in two sizes: 6-inch and 8-inch.

Christen's invention began the age of apochromatic refractors. Today, manufacturers use between two and four lenses to produce APOs, as amateurs call them.

A year before Christen introduced his lens, optical designer Al Nagler designed the first ultra-wide-field eyepiece. Not sure if amateurs at the time would pay $200 for an accessory, Nagler visited star parties to demonstrate his eyepiece. Observers raved about the 13mm Nagler eyepiece, which combined an 82° apparent field of view with tack-sharp images across the entire field. Tele Vue Optics'

The Riverside Telescope Makers Conference held its first get-together in 1969. Since 1975, amateurs have met near Big Bear City, California, during the 3-day Memorial Day weekend. Tom Polakis

place in the history of amateur astronomy was secure.

For the next decade, better optics, more accurate drives, and accessories of all kinds helped improve the viewing experience of amateur astronomers. Then, in 1994, Meade Instruments Corp. of Irvine, California, dropped a bombshell — it introduced Autostar, the first computerized go-to system for commercial telescopes.

The introduction of go-to drives opened up amateur astronomy to everyone. Suddenly, observers didn't have to know celestial coordinates or be able to read star charts — they didn't even have to recognize constellations.

A go-to drive, once properly set up, would acquire any of thousands of celestial objects manufacturers put into their databases and track those objects as they moved across the sky. Simplified observing had arrived.

The 1990s also saw the development of high-level astroimaging made possible by charge-coupled device (CCD) cameras. This development so overtook amateurs that, as 2000 arrived, almost no astrophotographer shot the sky with film. The current decade has introduced astroimaging to a new, less technically oriented group through high-resolution digital SLR cameras.

Taking up the shield

As amateur astronomy developed in the United States, the population grew and cities expanded. Recently, groups of observers have banded together to fight an increasing problem caused by such growth: light pollution.

Initially, politicians and city administrators looked on such activities as a fringe movement to remove all outdoor lighting. But those in charge of budgets quickly realized their municipalities could save large sums of money by installing the right type of lighting.

Additionally, studies by the International Dark-Sky Association (IDA) and others suggest that shielded lighting, while benefiting amateur astronomy, is better for the environment. The IDA also points out light pollution's deleterious effects because human physiology requires more hours of darkness than many locations in America provide.

Composed mainly of amateur astronomers, the IDA incorporated in 1988. It has 5,000 members in 70 countries.

Thanks to the IDA and thousands of amateur astronomers, our hobby's future looks dark. And that's a good thing.

Meade's Autostar controller brought go-to computer control to amateur astronomy in 1994. *Astronomy*: William Zuback

Still going strong

All indicators — telescope sales, astronomy club memberships, astro-related web site visits, and magazine subscriptions — show that amateur astronomy continues to thrive. Even in our society, which offers more activities than ever before, people are taking time to look up at the sky and marvel.

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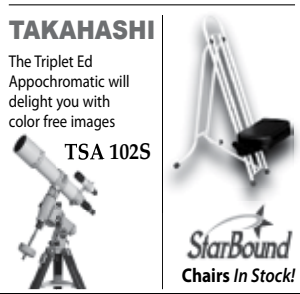

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Astronomy's *experts from around the globe answer your cosmic questions.*

How to watch a meteor shower

Q: What's the best way to observe a meteor shower?

— **James Bartel,** Evansville, Indiana

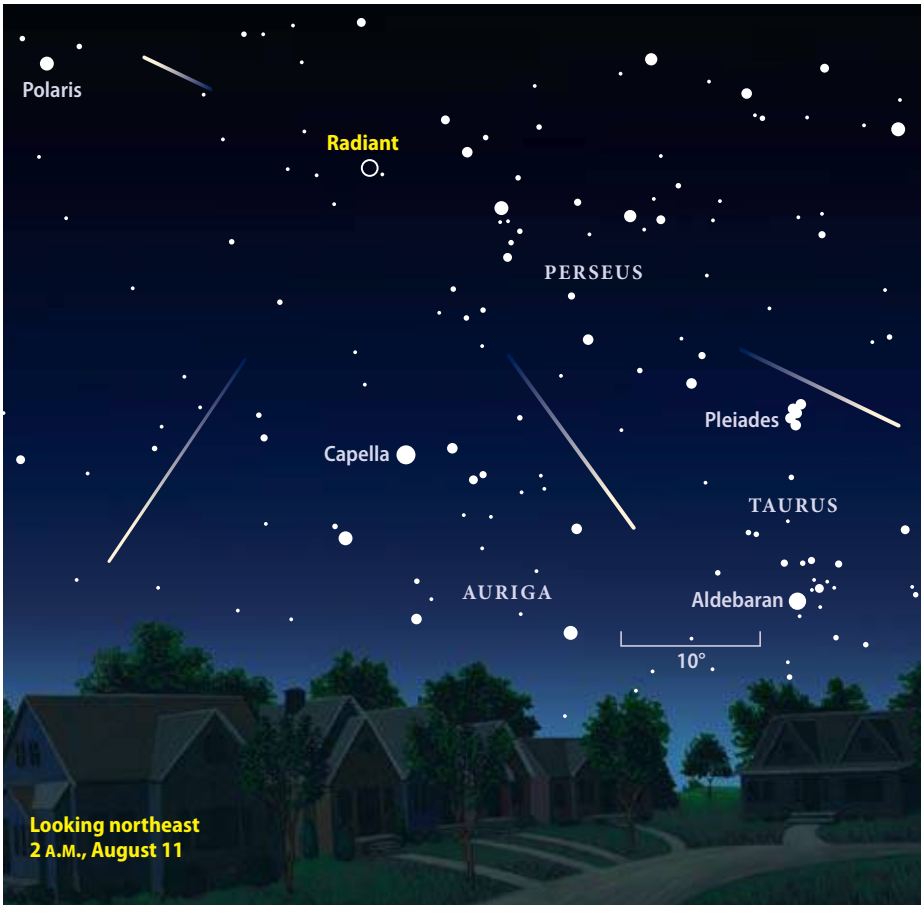
A: Viewing a meteor shower doesn't require any equipment. The eyes alone work best to spot "shooting stars." You will also need a clear, dark sky at least 40 miles (64 kilometers) from a large city's lights. A lawn chair, preferably one that reclines, will make your observing session more comfortable.

In addition to a chair, observers should think about bringing a blanket, bug spray, cookies, fruit, and a non-alcoholic beverage. Alcohol interferes with the eye's dark adaption and visual perception.

Early in the evening, set up your lawn chair. Face east, and look halfway up the sky from the horizon. After midnight, adjust the chair, and generally look overhead. Glancing around won't hurt anything.

Don't miss the Perseid meteor shower's peak August 11. Observers can expect to count between 60 and 90 meteors per hour from a dark site.

— **Michael E. Bakich,** Senior Editor



Perseid meteors appear to originate from a point near the top of the constellation Perseus. On August 11, look overhead after midnight to see the most meteors. *Astronomy*: Roen Kelly

BODY SHAPE

Q: How do planets, moons, and asteroids become round?

— **Sandra Lind,** Fairview, New Jersey

A: A body's gravity pulls all of its material toward its center of mass. The more massive the body, the rounder its shape. This means that giant gas planets like Jupiter and Saturn will tend to form into spherical shapes.

A body's spin and the tidal forces of other bodies can cause slight bulges. This is why the planets are not perfect spheres but rather shapes called "spheroids."

Rocky bodies like Earth can maintain some topography, like mountain ranges and ocean basins. But if a rocky body is large enough, its gravity may overwhelm the rock's strength and force the deep interior to "flow" into a spheroid.

Smaller solar system bodies with weak gravity often aren't round. Because of their low masses, asteroids, comets, and moons show a variety of shapes. For instance, the asteroid 216 Kleopatra resembles a giant dog bone, and Atlas, a small saturnian moon, looks like a flying saucer.

Even large objects can have unusual shapes. One Kuiper Belt object, called 2003 EL_{61}, is nearly as big as dwarf-planet Pluto, but it spins so rapidly that it's stretched out into a shape best described as a slightly squashed football.

— **David Minton,** Lunar and Planetary Laboratory, University of Arizona, Tucson

CURVED SPACE

Q: If photons have no mass, how can gravity bend light?

— **Matt Francis,** Kamas, Utah

A: According to Albert Einstein's theory of general relativity, published in 1915, gravity is equivalent to the curvature of space. Thus, any particle — no matter what its mass — travels in a distorted path as it passes by a massive body such as the Sun. But Einstein wasn't the first to notice this.

How do astronomers find exoplanets? Find out at www.Astronomy.com/toc.

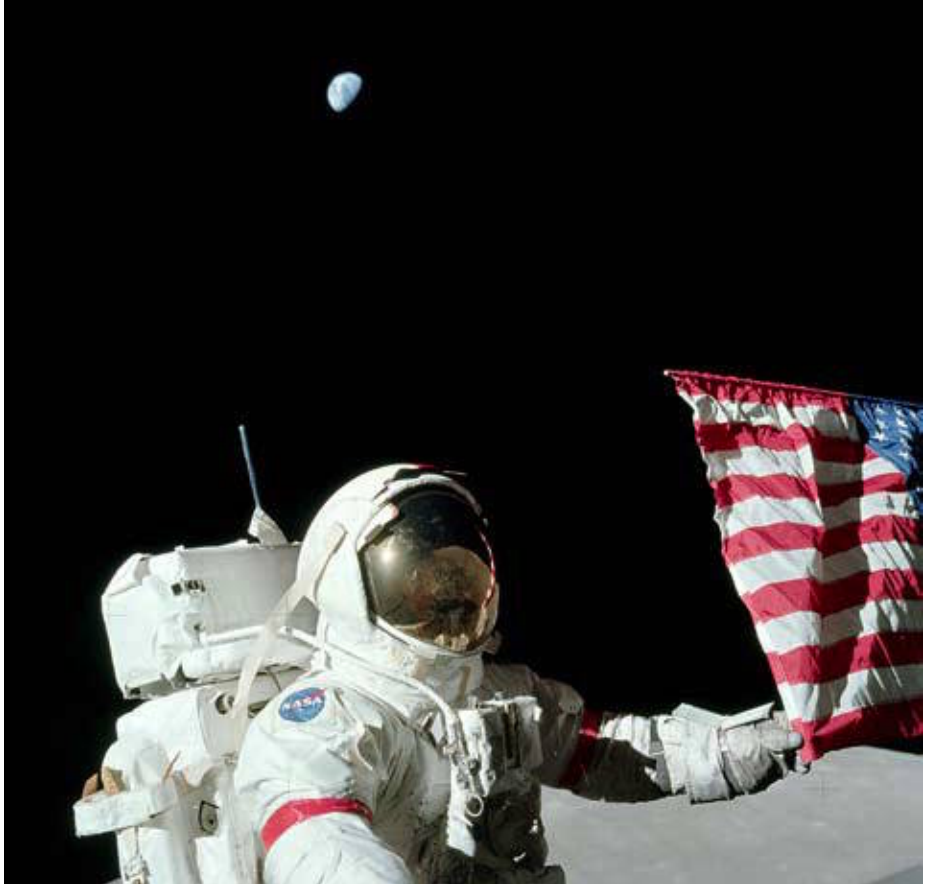
GLOSSARY OF TERMS

Meteor shower
Enhanced meteor activity that occurs when Earth collides with a swarm of debris; an individual shower occurs at the same time each year and has all its meteors appearing to radiate from a common point.

Spheroid
A shape that is nearly spherical; Earth is a spheroid.

Kuiper Belt
A region in the outer solar system beyond Neptune's orbit that contains billions of small, icy bodies; Pluto is the largest known Kuiper Belt object.

Dwarf planet
A celestial body that orbits the Sun, does not orbit another body, is massive enough to assume a nearly spherical shape, and has not cleared its orbital path of planetesimals and other debris.



Apollo 17 astronaut Harrison Schmitt saw Earth but no stars from the lunar surface December 13, 1972. Astronaut Eugene Cernan snapped this image at the Taurus-Littrow landing site. NASA

In 1804, more than 100 years before Einstein's theory, German astronomer Johann Georg von Soldner (1776–1833) applied Sir Isaac Newton's equation $F=ma$ — force equals mass times acceleration — to light, which was then thought of as particles. He found the Sun should deflect light passing near its limb.

The calculation works because the force in Newton's equation is proportional to m, the deflected particle's mass. Because mass drops out of the equation, the deflection even of massless particles can be calculated.

Einstein initially obtained the same answer as Soldner. After refining his theory, Einstein's general relativity predicts that light passing by the Sun is deflected by twice as much as Newton's theory predicts. Observations of stars displaced by the 1919 total solar eclipse famously confirmed that Einstein's result was correct. **— Scott Dodelson,** Center for Particle Astrophysics, Fermi National Accelerator Laboratory, Batavia, Illinois

MOON VIEW

Q: Would astronauts on the Moon observe Earth occulting background stars? — Sid Leach, Scottsdale, Arizona

A: Yes. An astronaut would see Earth's disk slowly occult the background stars and planets in the lunar night sky. As seen from the Moon, a Full Earth's bright disk might inhibit astronauts from seeing some of the dimmer stars, but most would be spectacularly visible in a jet black sky. However, the daytime view isn't so clear.

Even the brightest stars appear dim and difficult to see during daytime on the Moon. Plus, glare from sunlight diffusely reflected off the lunar surface dilates the pupils of the eyes. **— Paul D. Spudis,** Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland

ANCIENT COMETS

Q: How can astronomers know details about the appearances ancient comets? — David Aiken, Ada, Michigan

A: Most of what we know about ancient comets comes from Chinese annals, where astrologers carefully recorded observations of sunspots, eclipses, comets, and more. The Chinese system used 283 asterisms (think mini-constellations) and 28 "lunar mansions" arranged along the celestial equator.

The astrologers recorded comet tail lengths in units called *chi*. We now know a *chi* equals about 1.5 degrees.

Some observations of bright comets would give the position (asterism or lunar mansion), color, form and length of the tail, and the observation date and time. We know that diffuse naked-eye comets could not be discovered in a dark sky until they reached about magnitude 3.5. Once spotted, they could be followed to fainter magnitudes.

The Chinese often would record how long a particular comet remained visible. For bright periodic comets like 1P/Halley, modern observations have established its orbit and brightness behavior as it rounds the Sun. Today's astronomers can use the date of first observation and the total observation interval recorded by the Chinese to estimate how the comet looked in past apparitions. **— Donald K. Yeomans,** Jet Propulsion Laboratory, Pasadena, California

Send your questions via e-mail to: **askastro@astronomy.com**; or write to **Ask Astro, P. O. Box 1612, Waukesha, WI, 53187.** Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

Backstage at *Astronomy*

Putting out the world's most-read astronomy magazine requires many people with down-to-Earth publishing skills and deep-sky experience. **by Dick McNally**

It takes a universe of skills to produce a magazine like *Astronomy*. And after 35 years in print, *Astronomy* enjoys the luxury of having some of the best science journalists available on its staff. We employ people with expertise in calculating star charts (Richard Talcott), overall cosmological science (Francis Reddy), solid familiarity with telescope manufacturers and the hobby (Michael E. Bakich), and skill in writing about all areas of science (Daniel Pendick).

Astronomy is one of 15 magazines produced by Kalmbach Publishing Co. in Waukesha, Wisconsin. The company was founded in 1933 by Al Kalmbach when he started *Model Railroader* magazine. Kalmbach was just out of college.

Stephen Walther also was a young man – only 29 – when he founded *Astronomy* 35 years ago. Unfortunately, Walther died of a brain tumor only 4 years after starting the publication. Since then, the magazine has had four editors.

It takes a lot of leadership to maintain a smooth-running staff. Editor David J. Eicher, who took the helm in 2002, began his editing career at age 15 by starting *Deep Sky Monthly* magazine. He arrived at *Astronomy* when he was 21, bringing his magazine with him. Working as an assistant editor of *Astronomy*, Dave doubled as the *Deep Sky* editor for 10 years until the company ceased its publication.

Associate Editor Daniel Pendick (right) presents his plans to illustrate an article to Art Director LuAnn Williams Belter and Editor David J. Eicher. *Astronomy*: Dick McNally

Astronomy Art Director LuAnn Williams Belter (standing) discusses magazine layouts with Senior Editor Michael E. Bakich, Illustrator Elisabeth Roen Kelly, and other staff members .

Besides the hard-core astronomers mentioned, *Astronomy* also boasts people like Assistant Editor Jeremy McGovern who, though interested in astronomy, is more adept at keeping our web site at its best. Editorial Associate Valerie Penton is the unsung hero. She keeps all areas of administration humming, allowing other staff members to focus on what's going on in the universe. Editorial Intern Megan McChain is the roving project person who can write news and upload it on the web site, or complete any other task with minimal instruction.

Astronomy's art director, LuAnn Williams Belter, has more than 20 years of design experience and an amazing ability to grasp scientific concepts quickly. She's backed up by *Astronomy*'s illustrator, Elisabeth Roen Kelly, who is renowned for her many renderings over the past decade. Graphic designer Chuck Braasch unfailingly contributes excellent designs.

The magazine you are reading has been in production for some 6 months. In fact, Dave Eicher had all the articles

Astronomy **staff members, from bottom, left to right: LuAnn Williams Belter, Francis Reddy, Megan McChain, David J. Eicher, Laura Baird, Dick McNally, Valerie Penton, and Elisabeth Roen Kelly; top: Chuck Braasch, Richard Talcott, Jeremy McGovern, Michael E. Bakich, Daniel Pendick, and Kevin Keefe.** All photos *Astronomy*: William Zuback and James Forbes unless otherwise noted

selected and up on his issue planning board nearly a year ago.

When articles are assigned to freelancers, they usually are given 2 months to write their manuscripts. Then there's a month to prepare the manuscript, and acquire illustrations. Add another 30 days for design and layout, and allow 2 weeks for copyfitting and proofing.

The production department takes 2 weeks to prepare layouts for press. Then it's off to the printers, who require another month to print and distribute each monthly edition.

Magazine production goes on only 5 days a week, however. Our crew, collectively, does have a life after hours. Associate Editor Dan Pendick plays guitar in an Irish music group, and has been known to scuba dive on deep wrecks in the Atlantic Ocean. Dave Eicher frequently heads to Lambeau Field to cheer on the Packers in freezing weather. An accomplished author, Dave has eight astronomy

When layouts are completed each month, the staff meets to review the designs and see how the overall plan for the magazine looks when all articles can be seen together.

books and eight Civil War books in print. Also a drummer and guitarist, Dave hosts twice-monthly jam sessions at his house where he, his son Chris, and a group of Dave's fellow employees and other friends belt out blues and rock music for 3 hours.

Senior Editor Michael Bakich enjoys woodworking. He spends weekends making improvements to his house and building furniture. He also collects meteorites and 19th-century, first-edition astronomy books. Other activities (besides helping his artist/designer wife Holley prepare for her art shows) include following the Chicago Cubs and Kansas City Chiefs. Michael is an extraordinary public speaker, partly because of his years of giving presentations to audiences when he managed planetaria.

Senior Editor Frank Reddy, who seems to know more than a little about nearly everything (really!), likes to spend his time either learning from, programming, or fixing computers. Frank, who has won national writing awards in each of the past 2 years, is especially adept at finding data online from which to develop various types of graphic illustrations for the magazine.

Senior Editor Rich Talcott, who suffers from a severe case of New York Yankees and Giants fansmanship, studies Egyptology in his spare time. A former college mathematics professor, Rich produces sky charts with rock-solid accu-

Astronomy staff members

Michael Bakich

Senior Editor Michael E. Bakich is one of the most prolific writers/editors on the staff. *Atlas of the Stars*, *100 Most Spectacular Sky Wonders*, and *Hubble's Greatest Pictures*, all Michael's ideas, were tremendous hits. Michael also served as editor for those issues.

Michael has been fascinated with astronomy since the third grade, when his parents bought him a set of constellation flash cards. From then on, he wanted to become an astronomer.

He achieved his goal in 1975 when he received a bachelor's degree in astronomy from the Ohio State University. Later, he earned a master's in planetarium education from Michigan State University.

Michael joined *Astronomy* in 2003 as an associate editor. He was promoted to senior editor in 2006.

Before coming to *Astronomy,* Michael worked at seven planetaria over a period of 22 years. He also worked as a planetarium and museum consultant. At the magazine, besides being a productive writer and editor, he's our consultant for anything having to do with the hobby.

LuAnn Williams Belter

Art Director LuAnn Williams Belter's family heritage has largely been converting trees into art-filled paper. Her father worked in a Wisconsin paper mill and used to bring home gobs of paper for LuAnn to use for creative fun.

LuAnn still turns trees into art-filled paper, but her creative efforts are under more deadline pressure now. She guides designers and illustrators through the magazine layout process, and does a big part of the hands-on design herself.

A former owner and vice president of a design firm, LuAnn has the combination of creative skills and organizational capabilities to keep a steady flow of monthly magazines and special issues on track. Married and balancing her career with family responsibilities, LuAnn spends a significant portion of her free time following her two children's scholastic and athletic careers.

Chuck Braasch

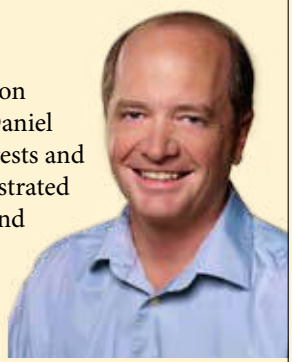
Graphic Designer Chuck Braasch is a colorful character — and that's a good thing in art design. He graduated from Madison Area Technical College in Wisconsin, and began working at Kalmbach in 2001.

Chuck has designed other Kalmbach publications as well. He left us for a couple of years to gain familiarity with other company magazines. But *Astronomy* was fortunate to get him back, and he's been a stalwart in keeping each issue colorful and vibrant.

Chuck says he always has looked to different outlets to inspire his imagination. "Friends aside, I've surrounded myself with movies – particularly with directors named Spielberg and Lucas – as well as comics, video and computer

gaming, books, modeling, and collecting toys."

What does all that have to do with Chuck's work at *Astronomy*? "I like making 'special effects' on paper for the magazine," he says.



Paul Daniel

Group Circulation Manager Paul Daniel has a lot of interests and ideas, as demonstrated by his background and hobbies. A TV sportscaster for 10 years, Paul flies private airplanes, rides motorcycles, flies radio-control aircraft, plays golf, and, yes, observes the night skies.

A graduate of the University of Wisconsin-Milwaukee with a degree in marketing, Paul created award-winning marketing programs in previous positions before coming to *Astronomy* last year. He's already off to a dynamic start at Kalmbach, demonstrating the skills required to sell *Astronomy* to interested readers.

David J. Eicher

Editor David J. Eicher has worked at *Astronomy* for more than half of his life. He started as an assistant editor at age 21 and has held every position on the magazine since then.

When Dave came to work for *Astronomy*, he brought along a sidekick: his *Deep Sky Monthly* magazine, which he had founded as a high school kid. He worried that, when he went out into the working world, he would no longer be able to operate his monthly. But out of the clear blue, then-*Astronomy* Editor Richard Berry called Dave with an employment offer — and an opportunity to let Dave publish his magazine under *Astronomy*'s auspices.

The young entrepreneur was delighted. "Allowing me to continue my magazine was an offer I couldn't refuse," he says. "No one wants to kill their baby."

Dave continued his "double life" as *Deep Sky* editor and *Astronomy* assistant editor (and, later, associate editor) for 10 years, until it became impossible to fill both roles effectively. "To the company's credit, it would have continued to publish *Deep Sky,*" Dave says, "But the time constraints made it impossible."

Now, Dave has parlayed his childhood gambit into the editorship of the world's most widely read astronomy magazine. He lives in the countryside southwest of Milwaukee with his wife Lynda and son Chris.

Jeff Felbab

Advertising Manager Jeff Felbab just joined the staff in February, but he has been in advertising and marketing for some 15 years. His background includes magazine, Internet, radio, and television work.

Jeff, who grew up in Racine, Wisconsin, says he enjoys working with customers to tailor advertising plans that help their businesses achieve their goals. He earned a Bachelor of Business Administration degree in marketing at the University of Wisconsin - Whitewater.

Jeff also has a strong interest in astronomy. He was introduced to the hobby some 25 years ago by his father. "I remember the first time my dad pointed the telescope toward Saturn and told me to take a look," he says. Some astroimages shot by Jeff's dad have appeared in *Astronomy*.

Jeff's other interests include lots of outdoor activities, including boating and bike-riding. He also likes to read and play guitar.

Craig Greuel

Advertising Representative Craig Greuel earned a bachelor's degree in marketing from the University of Wisconsin-Oshkosh. He joined Kalmbach in 1997 and has contributed his sales efforts to several magazines since then. Before coming to Kalmbach, Craig held advertising sales positions with trade publications that specialized in agribusiness and metals industries.

A Wisconsin native, Craig enjoys taking advantage of the state's beautiful outdoors. He camps, hikes, and bikes at various state parks. He lives in a Milwaukee suburb with his wife Brenda and children Madeline, Evan, and Aidan.

Kevin P. Keefe

Publisher/Editorial Vice President Kevin P. Keefe came to Kalmbach to work on *Trains* magazine. He eventually served as editor of that publication for 8 years before being promoted to associate publisher, then publisher and vice president.

Kevin worked on daily newspapers in Michigan and Wisconsin early in his 35-year journalism career. Now, as publisher and vice president/editorial, he is responsible for editorial operations of Kalmbach's 15 magazines. He has direct publisher responsibilities for *Astronomy*, *Trains*, *Classic Trains*, and *Birder's World*.

The publisher developed his interest in astronomy when he attended a summer YMCA camp while growing up in southern Michigan near Three Rivers. "The camp had an observatory on an island in Lake Corey," he says, "And during late-night sessions I learned the summer constellations and used the camp's 12-inch reflector." Nowadays, Kevin keeps very busy observing budgets and advertising, but still reserves some time to get out and spot familiar deep-sky objects.

Kalmbach Publishing produces *Astronomy* plus 14 other consumer magazines at its location just outside of Milwaukee, Wisconsin. The facility was built in 1989.

racy. His articles are so well prepared that corrections run on his stories could be collector's items.

This magazine wouldn't make it to your mailbox without the help of some non-astronomy experts. Nearly a third of the pages in the magazine are produced by the advertising sales force. Advertising Manager Jeff Felbab came to the magazine only this year, but brings 15 years of advertising sales experience. Advertising Representative Ken Kozerski has worked on the staff for 8 years. Advertising Representative Craig Greuel has worked for Kalmbach for 10 years, and recently joined *Astronomy*.

Our circulation experts, Paul Daniel and Sarah Zemplinski, make sure that the magazines we produce get sold. Paul, a former TV broadcaster, has been with *Astronomy* for a year and a half. Sarah started a year ago.

The ultimate number of people who contribute to *Astronomy* is nearly impossible to list. Freelance journalists and astronomy experts provide the "meat" of each issue. We have an enthusiastic group of astroimagers who regularly contribute their work. Columnists Bob Berman, Glenn Chaple, Phil Harrington, and Stephen James O'Meara are the personalities that readers look forward to each month.

A typical workday at *Astronomy* begins about 8:30 and goes to about 5:00. Often, one or two staff members are on the road attending seminars or star parties, or

Elisabeth Roen Kelly

Illustrator Elisabeth Roen Kelly earned a Bachelor of Science degree in medical illustration at the University of Toronto Medical College in Ontario, where she graduated with honors. Though her primary work now is illustrating cosmology stories, she still freelances medical renderings.

Along with some 10 years' experience at Kalmbach Publishing, Elisabeth has also illustrated several science textbooks. "It is one thing to make a beautiful piece of art, but to create something that makes the subject clear and more understandable to the reader — that is the ultimate challenge for me," she says.

Elisabeth also creates art for other Kalmbach publications, but her innate ability to understand complex scientific concepts drew her to specialize in illustrating for *Astronomy*. She won an American Astronomical Society Solar Physics Division Popular Writing Award in 2007 for her illustrations in "The Sun's biggest blasts," written by Francis Reddy.

Ken Kozerski

Advertising Representative Ken Kozerski is a night-sky observer. He's also a day-sky observer, but it might not be the hobby you think. "I love to fly kites on the shores of Lake Michigan," he says. "I probably have 25 two-handed stunt kites that I have been collecting and flying for over 25 years."

That's the same number of years he has sold advertising. Ken started in ad sales after earning a Bachelor of Science degree in urban planning at the University of Wisconsin - Green Bay. He came to work for *Astronomy* 8 years ago.

Ken began observing the night sky after joining *Astronomy*. "I was a complete novice, but discovered the passion and enthusiasm of fellow amateur astronomers and quickly built up a small stash of refractors that I still use today," he says. "I live with fairly dark skies and enjoy taking the scopes out for a spin around the backyard."

Megan McChain

Editorial Intern Megan McChain is everything we would want an intern to be: enthusiastic, knowledgeable, capable, and willing to take every opportunity to learn. She works another job besides her internship and still goes to school full-time. You'd never know her heavy schedule, however, by the energy she puts into her work.

Megan is a junior working on a journalism degree at Marquette University. At *Astronomy*, she uploads news onto the Internet, writes news and press releases for the web and magazine, and makes herself useful in a variety of other ways. She helped with the launch of *Astronomy*'s redesigned web site in November 2007.

The intern has spent most of her life in Milwaukee, where she was active with an Irish Dance group and worked as a counselor at a summer camp. Playing co-ed softball is one of her favorite activities now.

Jeremy McGovern

Assistant Editor Jeremy McGovern is the staff member most heavily involved with *Astronomy*'s web site. He monitors web activity and keeps tabs on the site's performance.

After working as a proofreader and researcher at Philadelphia's North American Publish-

ing, the Purdue University graduate attended Marquette University Law School. But he decided against becoming a lawyer and came to work for Astronomy.com in 2000. Since then, he has also become involved with the magazine, handling monthly departments and writing occasional features.

Jeremy spearheads – and suggests – improvements to Astronomy.com. When someone proposed using the web site to conduct *Astronomy* cover surveys, Jeremy conceived and executed the plan. It served as the model for other Kalmbach magazines that later did the same thing.

An inveterate blogger, Jeremy has developed a reputation for wry humor that will slip right past the unwary. Completely at home with web technology and style, Jeremy has made a large impact on Astronomy.com.

When he's not working at his computer, Jeremy enjoys representing the magazine at star parties and on tours. Those trips have allowed him to fly in seaplanes, hike up mountains, camp in Canadian woods and on the rim of the Grand Canyon, and observe on the Florida coast.

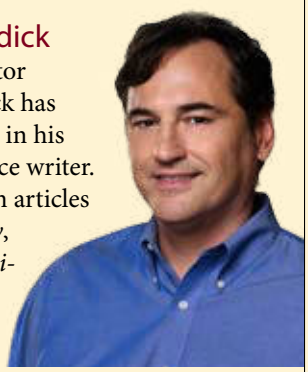
Dick McNally

Executive Editor Dick McNally has worked at Kalmbach for 10 years, with 4 of them at *Astronomy*. He has managed publications staffs for three decades.

Dick is a retired Air Force veteran who flew rescue helicopters in Southeast Asia and stateside in the early 1970s. After leaving the Air Force, Dick flew as a crop-duster pilot. Later, after taking out a second mortgage on his house, he started his own helicopter service in Arkansas.

But when the flying business failed to climb to the required altitude of profitability, the pilot diverted to an alternate career location. Thus, Dick began his journalism career as a reporter/photographer for two North Dakota weeklies. He was promoted to managing editor, and ran the newspapers for an absent publisher.

Dick continued his journalism career as an Air Force public affairs officer. He managed publications in U. S., Europe and Middle East tours of duty. One of his favorite assignments was as managing editor of *Airman*, the official magazine of the U.S. Air Force.



Daniel Pendick

Associate Editor Daniel Pendick has many notches in his pen as a science writer. He has written articles for *Astronomy*, *Earth*, *New Scientist*, *Science News*, *Sea Frontiers*, and *Underwater USA*. He also has served as the editor or writer for medical newsletters, including *Brain Work*, *Focus on Health Aging*, *Men's Health Advisor*, *Cleveland Clinic Heart Advisor*, and *Memory Loss & the Brain.*

Dan returned to Kalmbach in 2007 after working here previously as an associate editor of *Earth*, which Kalmbach discontinued in 1998. Besides freelancing during the interlude, Dan was selected as a Knight Science Journalism Fellow, a 1-year academic fellowship for midcareer journalists.

He holds an associate's degree in electrical technology (Suffolk County Community College in Selden, New York), a bachelor's in literature and rhetoric (Binghamton University in New York), and a master's in the history of science and medicine (University of Wisconsin - Madison).

A certified deep-water diver, Dan was an invited speaker for the meeting of the International Water History Association and UNESCO International Hydrological Programme, Paris, in December 2005.

With those credentials, it's easy to see why *Astronomy*'s editors were thrilled to bring Dan back to Kalmbach. Although *Earth* is gone, we're glad to have him covering the universe.

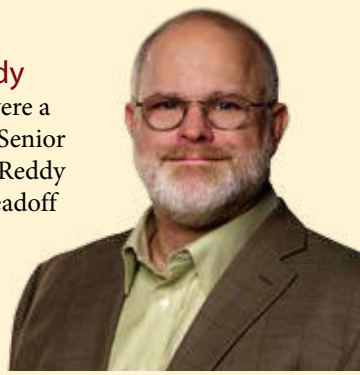
Valerie Penton

No one is better at what Editorial Associate Valerie Penton does. Working virtually autonomously, she keeps the administrative functions of *Astronomy* operating as smoothly as a Swiss watch. Producing contracts, issuing payments, editing magazine departments, you name it — giving Valerie a job is the equivalent of putting an airplane on autopilot.

With previous experience as a secretary, executive secretary, and office manager, Valerie came to *Astronomy* as an editorial assistant in 2003. Her responsibilities constantly increased due to her abilities, and she was promoted to editorial associate in 2007.

Valerie enjoys quilting, crafts, and other hobbies. She even has an associate certificate in cake decorating and has won several prizes.

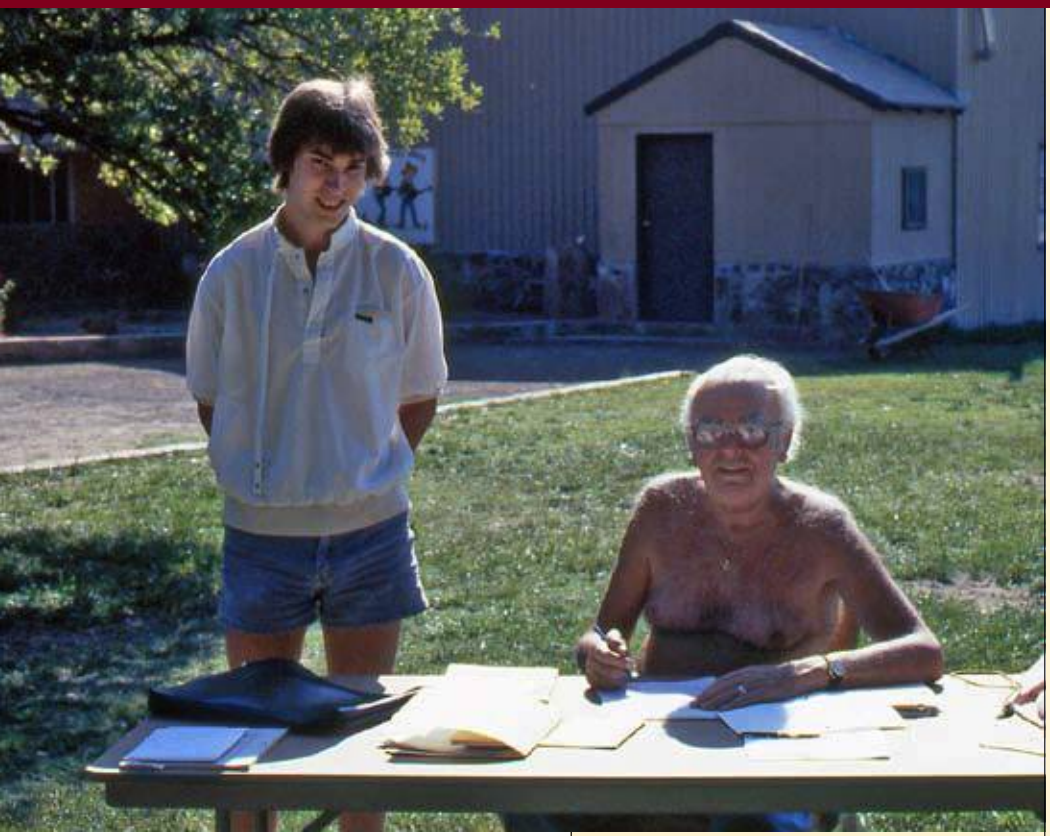
Valerie puts her talents to good use with projects including sewing Christmas stockings for troops in Iraq and blankets for kittens at Elmbrook Humane Society.



Francis Reddy

If *Astronomy* were a baseball team, Senior Editor Francis Reddy would be the leadoff batter. He can always be counted on to come through with a hit when the staff needs an idea. Furthermore, he always carries that idea through to a successful and sometimes award-winning result.

Frank, mostly through curiosity, stays abreast of the broad field of science dealing with astronomy and frequently acts as a sort of in-house guru on cosmology questions. With a degree in science journalism, he also has worked as a computer programmer, technician, and web developer.



Dave Eicher, then a college student and the *Deep Sky Monthly* editor, visits with Bart J. Bok at the Texas Star Party in 1982.

hosting *Astronomy* tours. Traveling and meeting our audience and contributors are highlights of the business we enjoy.

The staff realizes that the astronomy experts they meet today may be the luminaries they will remember tomorrow. Dave Eicher recalls that, early in his career, while attending astronomy events, he had the opportunity to visit with the likes of Bart J.Bok, for whom Bok Globules are named; Carl Sagan, of the TV series *Cosmos*; and Clyde Tombaugh, who discovered Pluto. As a relative novice astronomer, Dave found that all three took pains to make him feel welcome and answered all his questions.

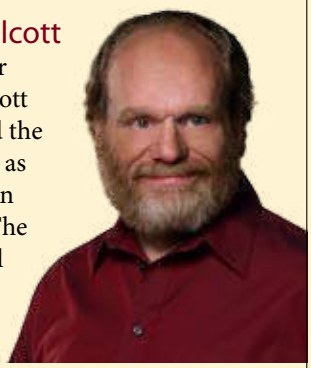
"That's typical of nearly all the people we meet in this business," Dave says. "Most have their eyes on the sky and they just want to share what they see."

We'd like to thank all of the current astronomers who, like icons of the past, are committed to sharing what they see with *Astronomy*. We're also indebted to our astroimagers, writers, and, of course, our readers. With your continued help and enthusiasm, *Astronomy* will enjoy at least another 35 successful years of reporting on the universe.

The senior editor's computer knowledge was critically important when the *Astronomy* staff redesigned its web site. His expertise was indispensable to the successful implementation of the site's almanac and interactive star atlas.

A book author and former freelance magazine writer, Frank has won two awards for his writing while at *Astronomy*. Among them are the 2007 Bronze Eddie for his "Top 10 Stories of 2006," and a 2007 American Astronomical Society Solar Physics Division's Popular Writing Award for "The Sun's biggest blasts" (This award was shared with *Astronomy* Illustrator Elisabeth Roen Kelly).

Richard Talcott



Senior Editor Richard Talcott has observed the night sky for as long as he can remember. The astronomical moment he remembers most is the solar eclipse he watched July 11, 1991 from Baja California in Mexico.

Like some others at *Astronomy*, Rich has turned his passion into a career. He represents the kind of editor sought by any science magazine: someone who knows writing as well as he knows science.

The senior editor earned a mathematics degree at Marietta College in Marietta, Ohio, in 1976. He attended graduate school at the Ohio State University, and returned to Marietta in the early 1980s as a lecturer in the physics department.

Since joining the *Astronomy* staff in 1986, Rich has written more than 100 science articles. He collaborated with Joel Harris to write *Chasing the Shadow: An Observer's Guide to Eclipses*, a book published by Kalmbach in 1994. He has produced *Astronomy*'s *Deep Space Mysteries* wall calendar for the past 20 years.

Sarah Zemplinski

Circulation Coordinator Sarah Zemplinski joined *Astronomy* in August 2007, in her first full-time position since graduating from the University of Wisconsin - Milwaukee last year. She holds a bachelor's degree in marketing and a certificate in international business.

Before coming to Kalmbach, Sarah completed a marketing internship with a Milwaukee insurance company. "It's exciting to work on a magazine," she says, "And I enjoy learning more about the hobby."

Sarah enjoys going to summer festivals and Milwaukee Brewers games, as well as spending time at the lake. She also likes cooking, running, and attending Milwaukee's theaters. Sarah looks forward to a couple of new activities this year: visiting Las Vegas, and skydiving.

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Who really invented the telescope?

Four hundred years ago, Hans Lipperhey's simple invention changed the world.

by Raymond Shubinski

Hans Lipperhey independently invented the telescope. Whether he was the first to come up with the device remains in question. Lipperhey did apply for the first patent for a telescope.

Michael E. Bakich library

Stadtholder (steward) Maurice, who ruled from 1585 to 1625, climbed the stairs of his residence in The Hague, the Netherlands, with a spectacle-maker from the nearby town of Middleburg. When they reached the roof, the craftsman handed his ruler a pasteboard tube with lenses mounted at either end. Looking through this device, the Stadtholder viewed the countryside. At that moment, the lensmaker's name — Hans Lipperhey (1570–1619) — became forever linked with the telescope.

In late September 1608, Maurice used this new device to spot the clock tower in the town of Delft, about 5 miles away. The Stadtholder also could make out the windows of a church in the city of Leiden, almost twice Delft's distance.

As leader of the young Dutch republic, Maurice was in a desperate struggle to free the Low Countries from Spanish rule and realized the military value of the new magnifying device. Lipperhey no doubt felt his future was secure, and that a patent on his optical tube was a sure thing.

A matter of priority?

Lipperhey's telescope was the result of centuries of development. Existing technology and the complex and unsettled political situation of early 17th-century Europe had as much to do with the appearance of the telescope as inspiration and invention. Lipperhey was only one of many individuals who seem to have hit upon the idea at about the same time.

Shadowy stories and outright exaggerations existed about "a tube for seeing" for more than 1,000 years. First-century Greek writer Diodorus claimed a northern race called the Hyperboreans could see features such as mountains and valleys on the Moon. Could these be hints from travelers' tales of Stonehenge and its builders?

The 13th-century monk and mystic Rodger Bacon asserted that Julius Caesar had a mirrored device with which he studied Britain's coast before his invasion in 54 B.C. Bacon spent many years in church dungeons for practicing alchemy and because some of his contemporaries accused him of being a wizard.

This Italian telescope is one of the jewels of the Adler Planetarium's instrument collection. This instrument, whose maker is unidentified, is one of only six known telescopes made before 1650.

Adler Planetarium and Astronomy Museum

Others who may have developed a pre-17th-century telescope include Italian inventor Leonardo Da Vinci (1452–1519) and English astronomer Thomas Digges (1546–1595). In 1570, Digges wrote of a glass that allowed him to "discover things farre off." He may have been using mirrors. Englishman William Bourne (1535–1582), a contemporary of Digges, described the use of lenses to view objects.

Another possible telescope inventor was Italian scholar Giambattista della Porta (1535–1615). In 1589, della Porta published *Natural Magic*. In the book's optics section, he described the use of convex and concave lenses. He even talked about fitting the two types of

Perhaps the first target Stadtholder Maurice of the Netherlands spotted through Lipperhey's telescope was the clock tower in Delft.
Raymond Shubinski

lenses together to help people with poor vision. It's unlikely that della Porta created a working telescope, however.

By the late 16th century, all elements were available to make a simple telescope. Those familiar with optics had known of the magnifying properties of convex lenses since ancient times. Archeologists have discovered many such lenses. The best-known is the 7th-century B.C. Nimrud lens fashioned from rock crystal (quartz) and discovered in the ruins of Nimrud Palace in what is now Iraq.

Only at the end of the 13th century did glass quality reach the point that opticians were able to grind lenses for spectacles. The concave lens wasn't in common use until the late 15th century.

An idea whose time had come

Fast-forward to Hans Lipperhey's rooftop demo for Stadtholder Maurice. As the two men spoke, Lipperhey expressed hope for a patent on his optical tube and a contract from the States General (the Dutch Parliament) to manufacture it. It was no accident that he first showed this device to a military leader.

Lipperhey's telescope design incorporated a convex lens as the objective at the front of the tube and a concave lens as an eyepiece. It gave an upright image, unlike today's astronomical refractor, which flips it. Historians call this design the Galilean telescope, after Italian astronomer Galileo Galilei (1564–1642), who first applied it to astronomy.

Lipperhey left no record as to how he developed a telescope. One story tells of children playing with lenses in his shop, making the discovery by chance. It seems

Giambattista della Porta, an Italian scholar, published *Natural Magic* in 1589. In this book, he described various types of lenses and fitting them together to help those with poor vision.
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1608.

AMBASSADES
DV ROY
DE SIAM EN-
VOYE' A L'EXCEL-
lence du Prince Maurice,
arriué à la Haye le
10. Septemb.
1608.

L'an de grace 1608.

In 1608, this pamphlet appeared within 2 weeks of Lipperhey's request for a patent on his telescope. It helped spread the word of Lipperhey's discovery. Only two original copies of this pamphlet exist. This is a copy of a reproduction. Raymond Shubinski

more likely that Lipperhey either found the lens combination during his own experiments or learned of it from rumors circulating at the time. Lipperhey applied for a patent October 2, 1608. That's when his hopes were dashed.

About that patent …

A committee met to consider Lipperhey's patent application and ordered him to keep his invention under wraps. Then the committee made an odd request. It instructed Lipperhey to make six sets of binoculars containing rock-crystal lenses. Lipperhey was given an advance payment, and he went home to fill the order.

On October 17, 1608, Jacob Metius showed up on the doorstep of the States General with a telescope in hand. Metius was from Alkmeer in the northern Netherlands. He told the reviewing committee he had been working on his telescope for 2 years and wanted a patent.

A letter to the committee from officials in Lipperhey's hometown claimed a number of other telescope-makers in Middleburg were manufacturing the gadget. So much for secrecy!

Dutch astronomer and historian Antonie Pannekoek (1873–1960), wrote that Sacharias Janssen (1585–1632), also of Middleburg, constructed a telescope in 1604. Janssen had been selling telescopes at fairs in Germany in September 1608. To further complicate matters, Pannekoek indicated Janssen had seen a telescope made by an unknown Italian some years earlier. Janssen invented the microscope in 1618.

Lipperhey arrived in The Hague while a delegation from Siam (modern-day Thailand) was visiting Stadtholder Maurice. The Siamese ambassador mentioned that Lipperhey appeared to be a "humble, religious and God-fearing man." The ambassador had the opportunity to point the tube toward the stars and noted he could see much more than with his unaided eyes.

A pamphlet mentioning the telescope appeared within 2 weeks of Lipperhey's request for a patent. The pamphlet's writer described the delegation in some detail and mentioned this new invention as an afterthought. Only two examples of this pamphlet survive but, in 1608, word of the new invention spread like wildfire. By spring 1609, Paris merchants were selling telescopes; examples appeared in other shops throughout Europe.

Sacharias Janssen, a contemporary of Lipperhey who also lived in Middleburg, may have built a telescope as early as 1604. By 1608, he was selling telescopes at fairs. In 1618, Janssen invented the microscope. Michael E. Bakich library

Despite Lipperhey's failure to secure a patent on the device, he dutifully delivered the requested binoculars. The committee found the devices to be "useful," and paid Lipperhey for his work.

The Italian connection

By May 1609, news of the "wonder toy" had reached Galileo in Padua, Italy. He realized the financial potential of this "perspective tube," as some called it, and quickly produced a better version. As soon as he had a good working model, he was off to Venice, where he demonstrated its military potential. Galileo's telescope allowed spotting a ship much earlier than well-trained lookouts.

Profit also excited the merchants of Venice. Inbound ships hoisted flags indicating the type of cargo they had on board. With the telescope, merchants could spot the flags 2 hours sooner. That gave them time to slip down to the markets and fix prices on incoming goods.

In 1592, Galileo became a mathematics professor at the University of Padua. Then, he went home and turned his telescope on the Moon, planets, and stars. By spring 1610, Galileo reported his observations in *Sidereus Nuncius* (*The Sidereal Messenger*), which ensured his association with the early telescope.

What's in a name?

Finally, how did the telescope get its name? The States General in Holland referred to it as the device "which stretches light." Other Dutch names included the "Dutch trunk," "Perspective tube," and "Optic tube." The English dubbed it the "Spyglass."

On April 14, 1611, Prince Frederick Cesi, president and founder of the Accademia dei Lincei in Rome, gave a banquet in honor of Galileo. At this event, Cesi unveiled the name for this instrument. It came from the Greek tele for "far," and *skopein*, "to look or see." Combined, you get Teleskopos or telescopium and, hence, "telescope."

From autumn 1608 to spring 1611, the telescope turned the world of science and philosophy upside down. The instrument would continue to evolve, producing the far-reaching images of the universe we have 400 years after a humble, God-fearing man requested a patent on a simple tube with lenses.

Raymond Shubinski *is the director of the Atomic Testing Museum in Las Vegas and a contributing editor of* Astronomy.

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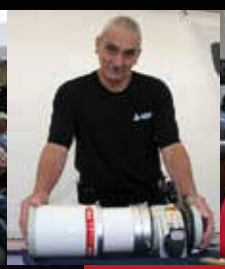

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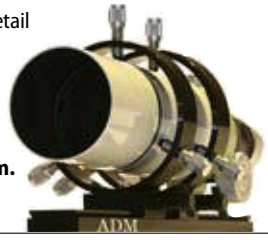

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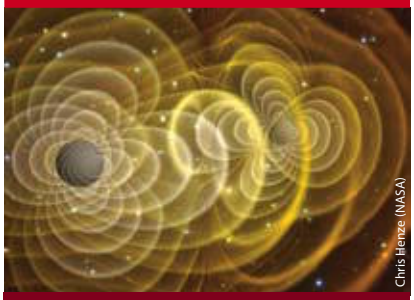

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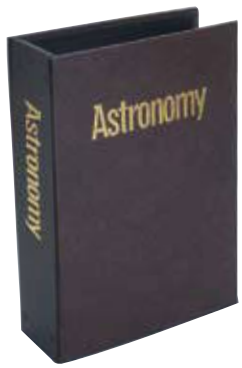

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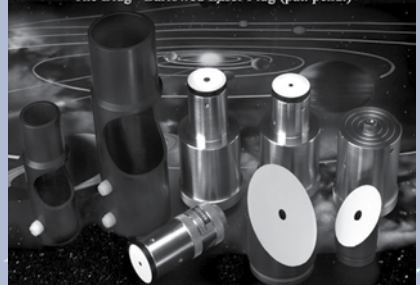

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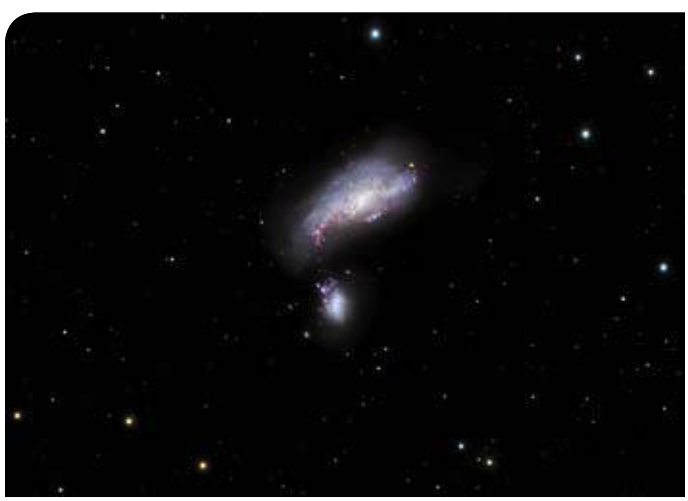
reader gallery

Polar star trails (Canon XTi DSLR, Sigma 8mm fisheye lens at f/3.5, ISO 400, thirty-six 10-minute exposures) • Chris Schur, Payson, Arizona

Shooting star trails

As Earth turns, the stars rotate endlessly around the celestial poles. Long exposures like the one above capture this motion. Such photos are easy to take. For this shot, Chris Schur attached his camera to a tripod and set a timer to produce 36 ten-minute exposures separated by 1 second. He then combined the images.

The brightest star near the picture's center is Polaris (Alpha [α] Ursae Minoris) — the North Star. It lies 0.77° from the north pole and the center of rotation. Long-exposure images also accentuate star colors, revealing a dynamic spectrum ranging from deep red to cobalt blue.



NGC 4490 AND NGC 4485 interact gravitationally. Located in Canes Venatici, NGC 4490, the larger galaxy, shines at magnitude 10.2. (9-inch TMB Super ED Apochromatic refractor at f/9, Starlight Xpress SXV H16 CCD camera, LRGB image with exposures of 135, 63, 63, and 63 minutes, respectively) • Dietmar Hager, St. Johann am Wimburg, Austria

< Emission nebula Sharpless 2–263 in Orion also contains a reflection component, which is the blue arc just above the brightest part of this image. (7.2-inch Takahashi Epsilon 180 hyperbolic astrograph at f/2.8, SBIG ST-10XME CCD camera, HαRGB image with exposures of 6, 2, 2, and 2 hours, respectively) • Dean Salman, Tucson, Arizona

V The Moon occulted Mars (dot at left) for 22 minutes in December, as seen from Bolu, Turkey. (8-inch Meade LX10 Schmidt-Cassegrain telescope, 17mm eyepiece, afocal projection with a Canon EOS 5D DSLR, 50mm lens, nine 1/60-second exposures, taken December 24, 2007, at 4h01m UT) • Tunç Tezel, Bursa, Turkey

^ Comet 17P/Holmes continues to impress as astrophotographers follow it. Here, Holmes appears next to the California Nebula (NGC 1499) in Perseus, which has a total magnitude of about 4. (Canon 200mm lens at f/2.8, Artemis 11002 CCD camera, RGB image with exposures of 20, 15, and 15 minutes, respectively, taken March 8, 2008, starting at 7:55 P.M. local time) • Gerald Rhemann, Vienna, Austria

> The Moon, Venus, and Mercury were bright enough to poke through the morning clouds when they gathered for a conjunction in early March. (Canon 350D digital SLR, 17-70mm Sigma lens set at 33mm and f/4, ISO 400, 10-second exposure, taken March 6, 2008, at 6:04 A.M. local time, from Terrigal Beach, New South Wales, Australia) • Mike Salway, Wyoming, Australia

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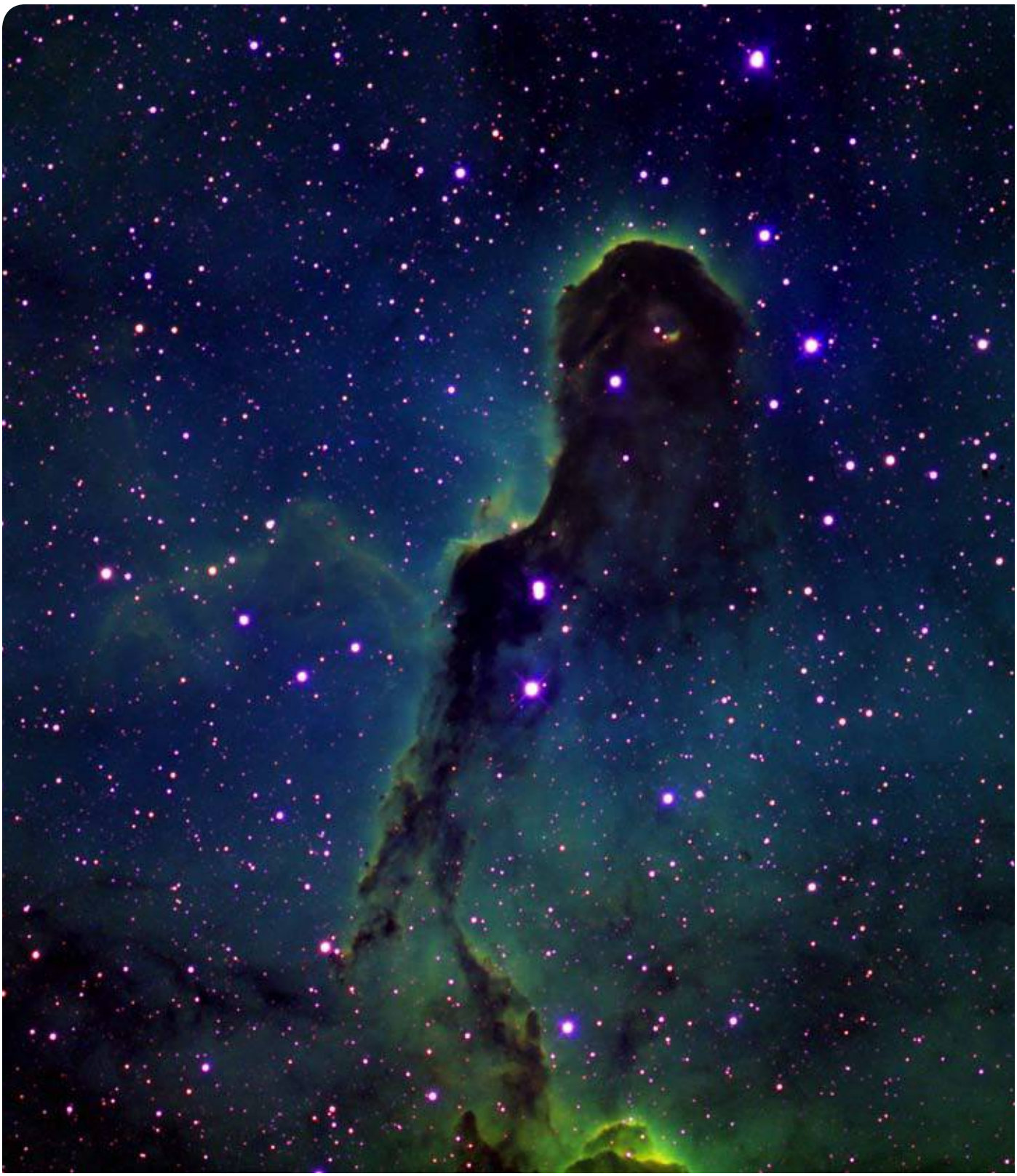

^ This image of the Elephant Trunk Nebula (IC 1396) in Cepheus required an astounding 68 hours of exposure time. IC 1396 is a faint star-forming area, which combines bright and dark nebulosity. It spans more than 3° and lies 3,000 light-years away. (12.5-inch RC Optical Systems Ritchey-Chrétien reflector, SBIG STL-6303E CCD camera, SII/Hα/OIII image with exposures of 18, 20, and 30 hours, respectively) • Brian Combs, Macon, Georgia

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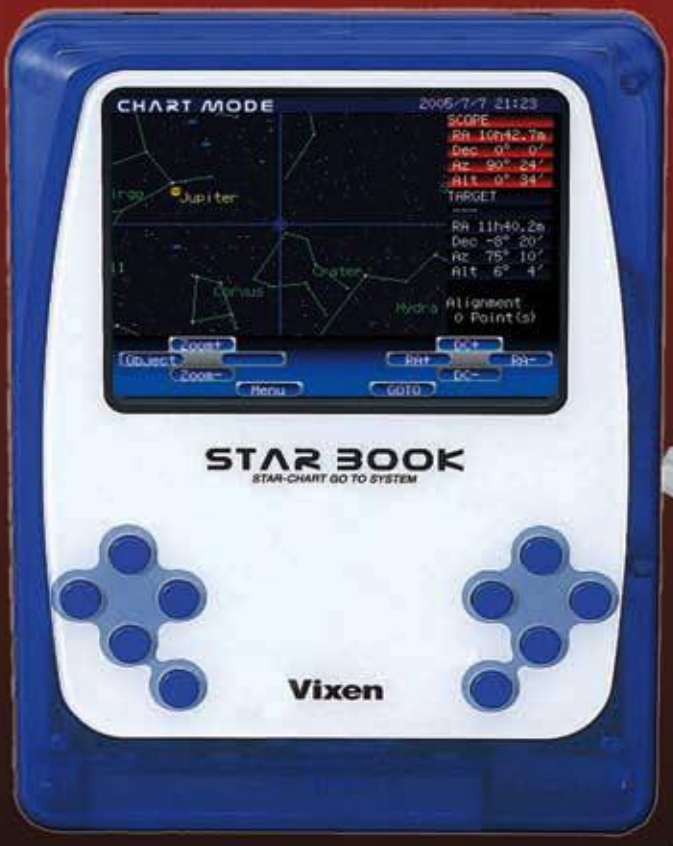

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